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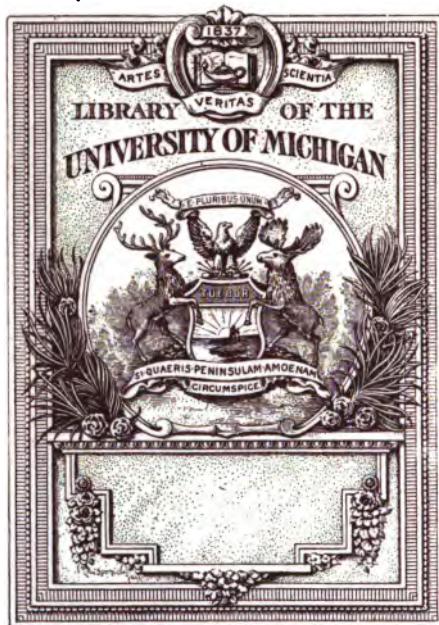
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SOUTHERN AGRICULTURE

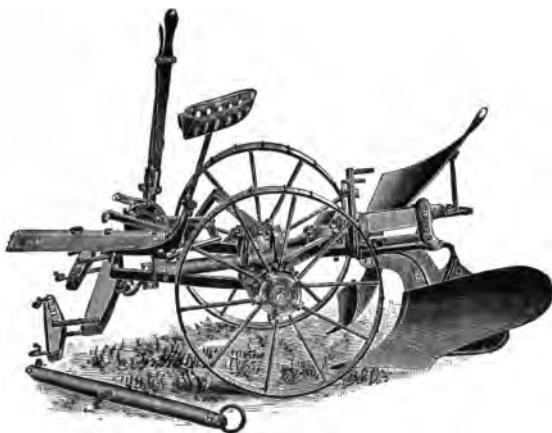


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Hillside Plow.



A Terraced Field.

SOUTHERN AGRICULTURE

BY
F. S. EARLE

New York
THE MACMILLAN COMPANY
1908

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Set up and electrotyped. Published April, 1908.

**Norwood Press
J. S. Cushing Co. — Berwick & Smith Co.
Norwood, Mass., U.S.A.**

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SOUTHERN AGRICULTURE

PART I

GENERAL CONSIDERATIONS

PRIMITIVE man obtained his food from the fruits and roots of various wild plants and from the flesh of wild animals. Agriculture began when he first took thought to care for his favorite food plants and to plant them near his usual haunts. The first crops doubtless sprang from the seeds of wild fruits carelessly scattered near the favorite camp or resting place. The fruits of these chance-sown plants were handy and easy to gather, hence the plants were cherished and to some extent protected from injury, while valueless plants would be broken down and destroyed. From such crude beginnings has modern agriculture sprung with its manifold labors and activities that have so wonderfully changed the face of the habitable part of the world, destroying the natural plant covering with its endless variety, and substituting great areas of those few plants that are of greatest utility to mankind. Agriculture is thus the propagation of plants through the intervention of man.

CLIMATE AS EFFECTING AGRICULTURE

The growth of wild plants is determined by two sets of factors, those connected with the soil and those connected with the climate. Cultivated plants are also subject to these same conditions except in so far as these may be modified by human effort. Cultivation is the collective name for all those processes by which man seeks to alter these environmental conditions, thus making them more favorable for his crops. It is easier to modify soil conditions than climatic conditions, hence the climate of any region must always profoundly influence its agriculture. Climate depends on the two factors of temperature and humidity. A climate may be hot or cold, wet or dry, and the kinds of crops that can be grown will vary accordingly. These factors depend in turn on three others,—latitude, altitude, and topography.

Latitude as effecting Climate.—If we start with the land of perpetual snow in the Arctic regions and travel southward, the climate will become gradually warmer and warmer until we reach the perpetual summer of the tropics. Each change in temperature will be accompanied by corresponding changes in plant and animal life. These changes are so well marked and conspicuous that naturalists are able to mark off a number of well-defined areas called life zones, each of which is characterized by the plants and animals found in it which do not occur either farther north or farther south. Other plants and animals have a wider range of adaptability and may

be found in more than one life zone, but even with these there is always a region where they thrive best and seem most at home. A study of these life zones in any country is of considerable practical importance to the farmer, for a knowledge of the life zone in which he is located will show at once what the probabilities of success will be with the different cultivated crops. Thus in the Hudsonian zone he can plant potatoes, turnips, and barley, but not corn. In the Alleghanian he can plant corn, wheat, and apples, but not cotton. In the Austro-riparian he can plant cotton, corn, and rice, but not apples and wheat.

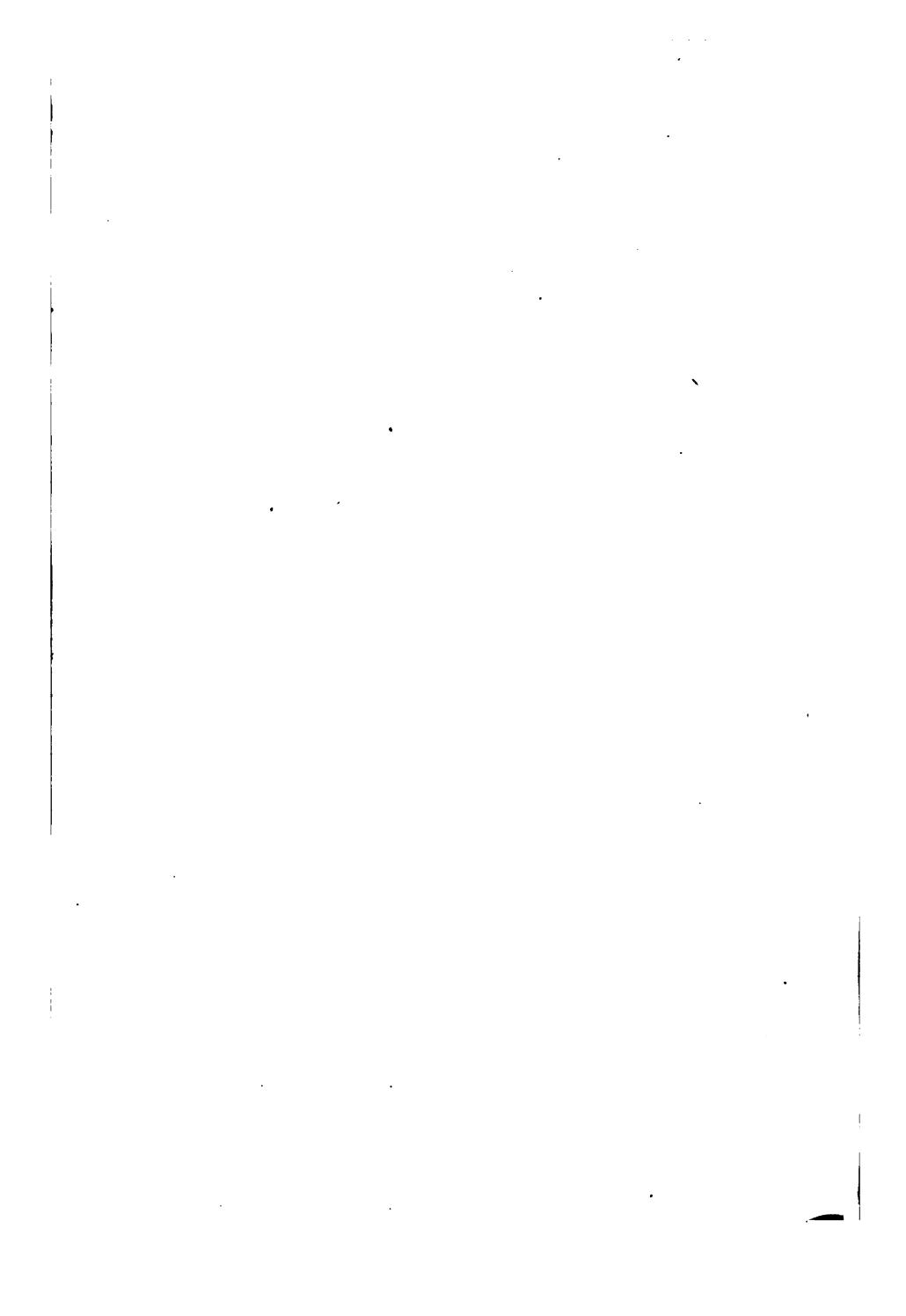
Altitude as effecting Climate. — If we pass from base to summit of a high mountain, we will find that altitude affects temperature in exactly the same way as latitude. Thus on every high mountain in the tropics, in the course of a few miles we may traverse all the life zones from the tropical jungles and perpetual heat of the base to the perpetual snow and ice of the summit. In fact, it is in mountainous countries that these life zones are most clearly marked. This is due to the fact that distances are so much shorter and comparisons so much more easily made. On level lands the boundaries usually overlap and are indistinct, but on steep mountains they are often very clearly marked, one kind of vegetation beginning and another ending very abruptly. The majority of wild animals and plants do not have a vertical range of more than a thousand feet.

Topography as effecting Climate. — A careful study of the life zones in a mountainous country will soon

show that the same zone is not always to be found at the same altitude. The plants of the cold thickets up near the timber line will be found straggling downward for a considerable distance in shaded ravines on the northern slopes, while on the side exposed to the sun the plants of the hot plains at the base may extend upward for many hundred feet.

In a level country like the great Mississippi Valley there is nothing to interrupt the free movement of the air, and the cold northwest winds of winter rush unchecked throughout its whole extent. If a great chain of mountains extended from east to west across the middle of it, these northerners would to a great extent be deflected and the southern portion would have a much warmer, more equable climate. On the other hand the warm winds from the Gulf of Mexico would be prevented from reaching the upper portion and its climate would be correspondingly colder. Italy owes its warm, genial climate to the protection of the Alps. Small local variations in altitude also have a pronounced effect on climate. The cool air at night settles into the low places, while the warmer air rises about the tops of the hills. In driving through the country at night every one has noticed the chill on descending into some damp ravine and the pleasant warmth encountered on the higher ridges. Fruit growers take advantage of this fact and locate peach orchards and strawberry fields on high ground, where they will be more likely to escape damage from spring frosts.

Topography is thus seen to have its effect on temperature, but it has an equally great effect in con-



A Moist Tropical Forest



trolling humidity. When a warm wind laden with moisture from the sea passes over the land, it becomes chilled in rising over high hills or mountains, since, as we have seen, these are cooler than the lower levels. Cool air cannot contain as much moisture as warm air, hence part of it is squeezed out and falls as rain. As a rule the windward side of a mountain range is wet, while the leeward side is dry. We thus find that the east coast of Mexico and Central America, which is exposed to the sweep of the northeast trade wind, has a heavy rainfall. In passing over the high mountains of the interior these warm, moist winds become cooled and lose their moisture, so that as they descend on the western side and again become warmed they are very dry. What are practically desert conditions prevail over large areas of the western side of these countries. The same thing occurs in South America and in the more mountainous of the West India Islands. Porto Rico and Jamaica have a very heavy rainfall on the north side of the mountains, but on the southern side it is so dry that irrigation is necessary for the profitable production of most crops. If our hypothetical chain of mountains extended across the Mississippi Valley, the south side would not only be warmer, but it would have much heavier rainfall, since more of the moisture from the Gulf would be deposited; while the northern side would not only be cold, but very dry.

THE SOIL

Formation of Soils. — The earth or finely divided substratum in which the ordinary land plants grow

and extend their roots is called the soil. It consists of more or less minute rock particles mixed with decomposed vegetable matter. The rocks that formed on the cooling of the earth's crust in the early geological ages soon began to be disintegrated by the action of rain and wind. As the cooling process continued the action of frost contributed largely to the same end. The loosened particles, swept along by the torrential rainfalls of this stormy epoch, were carried to the sea, where they were deposited to form the thick beds of stratified rocks which by subsequent elevation and erosion have served to furnish the material for most of our agricultural soils of to-day. During the long ages of the glacial period, when so much of the present temperate zone was covered with an immense sheet of ice and snow, the slow, irresistible, glacier-like southward movement of the mass also served as a powerful means for crushing and pulverizing the buried rocks below. From the earliest times running streams have been efficient agents not only for eroding rocks, but for transporting the disintegrated particles from one place and depositing them in another. As vegetation of various kinds began to appear on the sandbars and other exposed deposits of these crude rock particles, the remains of the dying plants became mingled with the sand and silt and by its modifying influence served little by little to form a true soil. Agricultural soils may, therefore, be classified according to their origin as alluvial deposits along streams; lacustrine deposits in the bottom of ponds and lakes, or the bottom of the sea, that have subsequently been elevated or drained by the

movements of the earth's crust; and glacial deposits left by the great ice sheet; or finally they may have been formed *in situ* by the slow weathering and decomposition of the underlying rocks. Bog soils are also worthy of special mention since they are mostly formed *in situ* from the remains of aquatic or semi-aquatic plants. Sand dunes and other shifting deposits made by the wind usually have but little agricultural value.

Kinds of Soils. — For practical purposes soils are usually classified according to the size of the particles of which they are composed. Among farmers they are spoken of as gravelly, sandy, loamy, or clayey, and intermediate grades are expressed by combinations of these terms, as sandy-loams, loamy-clay, etc. Soil physicists make a more accurate classification, which is expressed in the following table: —

- clay, soil particles, .005 mm. or less in diameter.
- fine silt, soil particles, .01-.005 mm. in diameter.
- silt, soil particles, .05-.01 mm. in diameter.
- very fine sand, soil particles, .1-.05 mm. in diameter.
- fine sand, soil particles, .25-.1 mm. in diameter.
- medium sand, soil particles, .5-.25 mm. in diameter.
- coarse sand, soil particles, 1-.5 mm. in diameter.
- gravel, soil particles, over 1 mm. in diameter.

In describing soils the shape of the soil particles is also taken into consideration. Of course most soils contain particles of different sizes. In making a mechanical analysis of a soil these particles are separated according to the sizes in the above table, and the percentage of each is determined. The adapta-

bility of a soil for different crops will depend very largely on these percentages.

Composition of Soils.—The chemical composition of soils naturally varies quite widely according to the nature of the rocks from which they have been derived and the climatic influences to which they have been subjected. The smallest particles constituting the clay are usually silicate of alumina, while the sand is mostly silica. These two substances in varying proportions form the great bulk of most soils, but they are both inert so far as supporting vegetation is concerned. A soil containing only these two substances would be absolutely sterile. Combined with these in varying quantities are usually found iron, carbonates and sulphates of lime and magnesia, and minute quantities of phosphate of lime and of nitrates, carbonates, chlorides, and silicates, of potash and soda. From a chemical point of view the fertility of the soil mostly depends on the small amounts of nitrates and phosphates and of potash which it contains. At least the other essential elements of plant food are usually sufficiently abundant in all soils, but the quantity of one or more of these three is often insufficient, especially in soils that have been long in cultivation. The solubility and therefore the availability of the phosphates and potash in the soil depends largely on the amount of vegetable matter which it contains. The nitrates, which may be considered the most important of all the soil substances, are mostly derived from decaying organic matter, so the amount of this material in the soil may often be taken as an index of its fertility. Bog soils, however, contain so large

a proportion of vegetable matter that the mineral elements are often in insufficient quantity. The presence of large quantities of lime in a soil gives it some characteristic peculiarities. The name of calcareous soils is applied where more than ten per cent of this substance is present. It usually happens that the surface layers of the soil contain more decomposed vegetable matter and so are darker colored than the part that lies below. This upper portion is called the top soil or surface soil, while the deeper layers are spoken of as the subsoil. The mechanical composition of the two is often quite different, and the line of demarcation between them may be clearly marked. The top soil may vary in depth from a few inches to as many feet. A deep surface soil is usually an indication of fertility. In some cases, as in the loess soils at some points along the Mississippi River and the red cane lands of the Tertiary period in the West Indies, there is no proper subsoil, since the surface soil extends downward practically unaltered for a great depth.

Biological Activities in the Soil.—So far only the chemical and physical properties of the soil have been considered. It is also the place for innumerable biological activities. Instead of being the inert, lifeless mass that it seems, it is literally swarming with untold myriads of minute living beings whose life processes profoundly affect its composition and properties. Without the aid of these active but infinitesimal workers the soil as we know it to-day could never have been built up; and if their activities should suddenly cease, its fertility would be

quickly lost, never to return. These bacteria, or germs, as they are often called, constitute the minutest forms of life. They are so small that they are scarcely more than visible under the highest powers of the microscope, but they occur in such numbers, their vital activities are so great, and they multiply so rapidly, that they constitute one of the most powerful factors in the world's economy. They are the agents of decay. It is by their aid that refuse animal and vegetable matter of all kinds is rotted down so that it may become incorporated in the soil and so become available for the growth of useful plants. Besides the numerous kinds whose combined activities result in this most useful work of decomposition there are many others, some highly beneficial and others noxious, whose activities in the soil strongly influence its quality and fertility. Some attack the ammoniacal compounds resulting from putrefaction and convert them into nitrites. Others in turn convert these nitrites into nitrates. It is only in the form of nitrates that our ordinary crops are able to use nitrogen as food, hence we see the immense practical importance of understanding how these salts are formed in the soil and of knowing how these processes may be influenced by different methods of cultivation. Nitrogen stored in the soil in other forms represents potential fertility, but it only becomes actual fertility after it has passed through those complicated changes known collectively as nitrification, which are produced by the combined action of these different living organisms and which result in the formation of nitrates. These nitrates are very soluble, and they are readily taken up in

dilute solutions by the absorptive surfaces of the root hairs found so abundantly near the ends of the young growing rootlets. Owing also to their extreme solubility, they are readily leached out of the soil and lost, and they are also liable to the attack of still other bacteria known as denitrifying organisms which set free the precious nitrogen and allow it to escape back to the great storehouse of the atmosphere. Losses from these two sources are often very heavy, and they are continually occurring in all cultivated soils that are not fully occupied by some actively growing crop, excepting of course when they are securely locked by the frosts of winter. The absence of frost and the fact that in consequence these manifold soil activities are progressing continuously throughout the year constitutes the chief real basic difference between southern and northern agriculture. This fundamental difference must always be kept clearly in mind when attempting to formulate rational agricultural practices for either region, or when attempting to adapt northern methods to southern conditions.

Besides this great series of organisms that we have seen to be concerned in the breaking down and putrefaction of organic matter and the subsequent conversion of the nitrogen it contains into the available nitrates, there is another series of bacteria known as nitrogen-fixing organisms which have the power which none of the higher plants possess of seizing the free nitrogen of the air and so combining it with other elements as to utilize it as food. It thus becomes organic nitrogen, and when excreted by these

organisms or on their death it is available for the growth of the higher plants after passing through the usual nitrifying changes. This ability to draw on the vast reserve of free nitrogen existing in the atmosphere is a matter of the utmost importance. The study of these biological activities in the soil which play so important a part in its fertility and consequently are so vitally important in the world's progress has only recently begun to receive attention. In the past few years many attempts have been made to propagate and artificially distribute these nitrogen-fixing bacteria and to learn the conditions which control their natural growth and increase in the soil. The problems involved are very complex and difficult and so far but few results of practical value have been obtained. The field remains an open one, and it is one of the most attractive and important in the whole range of the scientific investigations by means of which this age is striving to explain and to improve upon the ancient agricultural practices of the world.

There is one immensely important group of these nitrogen-fixing bacteria, however, whose activities are now fairly well understood and whose services are being utilized on a large and rapidly increasing scale. These organisms are parasitic on the roots of the numerous species of plants belonging to the bean and pea family or, as it is usually called, the *Leguminosae*. Their presence causes the growth of little galls or swellings known as nodules or tubercles, and in this respect they are to some extent an inconvenience to the plant. The favor of being fur-

nished a habitation and of being provided with a certain quantity of the sugary material which they take from the plant sap is amply repaid by their nitrogenous excretions which are in a form to be quickly available to the host plant. Plants of this family are thus enabled to grow and thrive in soils that are very deficient in nitrogen, since they are able to obtain a sufficient supply of this most necessary material from the atmosphere through the agency of these minute inhabitants of their root tubercles. The tissues of leguminous plants are rich in nitrogen, and they are more useful than any others to plow under for green manuring, since they really add to the soil large quantities of this ever desirable element. Other green crops and weeds when plowed under only return to the soil what they have previously taken from it. The fact that clover and other similar legumes were useful for green manuring has been known since the earliest times, but the reason why they are better than other kinds of plants for this purpose has only been known for a comparatively few years. Even when crops of clover, cowpeas, or other similar legumes are cut and removed from the land, the roots and stubble contain enough nitrogen to be of considerable use to succeeding crops. This is a matter of the utmost practical importance, since by establishing a proper rotation and by keeping the ground continuously covered by some leguminous catch crop when not occupied by the principal crop it is possible, at slight expense and without losing its use for a single season, to constantly maintain the nitrogen content of the soil and that without pur-

chasing a pound of this most expensive of the elements of fertility. When crops are constantly taken from the land, however, the potash and phosphoric acid will at length be exhausted, no matter how great its original fertility, and it will become necessary to supply them by purchase. The important question of methods for maintaining or improving the fertility of the soil will be more fully discussed in a subsequent chapter.

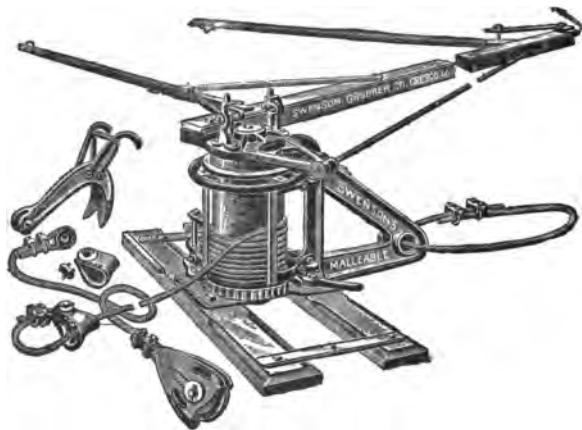
Besides the exceedingly useful organisms that have been so briefly discussed in the preceding paragraphs the soil frequently harbors others that may become exceedingly injurious by attacking and causing diseases in our cultivated plants or our domestic animals. As a general rule the richer a soil is in humus and decaying vegetable matter, the more likely it is to be able to support these noxious parasites, since some parasites are able to support life, at least for certain periods of their existence, on such decaying materials. It frequently happens that when the same crop is grown continuously on the same soil for a series of years, the land becomes so filled with some disease-producing organism that this crop can no longer be produced and its cultivation has to be abandoned. This again is too large a subject for full discussion here, but enough has been said to conclusively show that the study of the biology of the soil is fully as important as that of soil chemistry and soil physics. In fact chemistry, soil physics, and biology with its manifold branches, especially bacteriology and vegetable physiology and pathology, are the scientific foundation on which all rational farm

practices must depend. Agriculture itself is a business, not a science, but its nature is such that in order to conduct it successfully a knowledge is required of the results obtained by the students of many sciences.

MANAGEMENT OF THE SOIL

Preparation for Crops; Clearing.—In a state of nature arable soils, at least in humid or semihumid regions, are always covered with a dense growth of natural vegetation which it is necessary to destroy to make room for cultivated crops. In very arid regions extremely fertile soils are sometimes absolutely destitute of plant covering, but this is very rare. On forest lands the vegetation consists almost wholly of trees and shrubs, and the clearing is a serious labor; but on prairies or savannahs, where it consists entirely of grasses and other herbaceous plants, the whole may be turned under by the plow. The methods of clearing forest lands differ widely in different countries. In the tropics the work is usually very crudely done. The trees and bushes are hacked or chopped down with the machete or ax during the dry season and they are burned where they fall. The crop, whatever it may be, is now planted among the charred logs and stumps without any attempt at plowing the land, and such cultivation as is given is done with the hoe or machete. The plow is only employed when the smaller stumps are rotted and the land begins to be invaded by grass. In temperate regions the clearing is usually rather more thorough. The bushes and smaller trees are

taken up by the roots with the mattock, and the land is plowed with a "new ground plow," or jumping shovel, before the crop is planted. In either case it is ultimately necessary to dig out the remaining stumps and any large stones before the land can be fitted for cheap cultivation with improved modern machinery. Stump-pulling machines of various kinds are often



A Stump Puller.

employed in this work, and the larger stumps are frequently split in pieces by dynamite. In most cases it would probably be cheaper in the long run to do all this work in the first place and completely clear the land of all obstructions before beginning to plant it. This, however, entails so heavy an initial expense that it is seldom attempted.

Plowing. — The endless number of plows on the

market may all be referred to one of the three following types:—shovel plows, moldboard or turning plows, and disk plows. The first plow was probably little more than a crotched stick with the short arm of the crotch sharpened so that it could be dragged through the ground. In the evolution of the shovel plow from this primitive form a steel point was first added to protect the cutting end of the stick, and subsequently this point was flattened into a triangular shape and was slightly curved. The "Creole" or "Cuban" plow, still so much used in many parts of tropical America, has only reached the second stage in this development. It is only a steel-shod stick dragged through the ground. Shovel plows are largely used in laying off rows for planting and sometimes for cultivation, but they are but little used for the preliminary preparation of the land. Most modern cultivators are only gangs of small shovel plows.

The turning plow is the one mostly used for breaking up the soil in preparing it for planting. It is so called because it cuts out a clean furrow slice and turns it more or less completely over, thus burying all grass and weeds that are growing on the surface. It consists of a wooden or steel beam to which the team is attached, which corresponds to the long arm of the crotch in the primitive plow. To this is attached a standard which corresponds to the short arm of the crotch, and handles by which it is controlled by the plowman. The standard carries on one side a long, narrow vertical plate, the land side, which serves to hold the plow steadily to its work.

while on the other it has the share or point, which is a slightly curved steel or iron plate with a horizontal cutting edge which serves to cut out the furrow slice. It extends backward and upward to connect with the moldboard, which is another plate with a compound curve so shaped that the furrow slice is carried upward and is at the same time twisted over so that it falls wrong side up. Plows with differently shaped moldboards are adapted for handling different classes of soils. In gravelly or very sandy soils cheap cast-iron plows are often used, as the more expensive but softer steel ones are quickly ground away and worn out by the grit. On sticky lands that contain much clay it is necessary to use steel plows because the iron ones do not scour well, the soft dirt sticking to the moldboard and preventing the proper turning of the furrow slice.

Turning plows vary in size from those cutting a furrow slice only five or six inches wide to those cutting sixteen or eighteen inches, and they are adapted to be drawn by from one to as many as six or eight animals. The term "gang plow" is applied to those implements that carry two or more shares and moldboards arranged one behind another so that two or more furrows may be turned at each bout or turn around the field. Such implements can only be used on lands entirely free from obstructions. In the ordinary walking plows there is no mechanism for supporting the plow, but it is held upright and in place by the plowman. In riding or sulky plows the implement is attached to a frame that is carried by two or more wheels. The plowman rides and

controls the depth and position of the plow by means of levers.

The disk plow is entirely new in principle. It consists of a large circular knife or disk of thin steel which is pressed into a concave shape and mounted so as to revolve on a central axle. It is set so that the sharp edge enters the soil almost vertically and the furrow slice is lifted and turned over by the concavity of the revolving disk. Disk plows are



Double Disk Plow.

always riding plows. They may be single or arranged in gangs. They are very useful for certain purposes, especially in handling sticky refractory soils in which ordinary turning plows do not scour well.

Formerly plows were nearly always drawn by oxen. In tropical countries this is still the prevailing custom. The first cost of oxen is less than that of horses or mules; with good pasturage they can work on that alone without requiring expensive grain

feed, and when they reach an unprofitable age for work, they can be fattened and sold for beef. Oxen, however, move slowly and cannot endure as many hours of continuous labor as horses and mules. With a good span of mules a man can easily plow an acre a day in ordinary soils. He will do well to plow half an acre with a yoke of oxen. One man can manage eight horses and a sulky gang plow, but with four yoke of cattle it requires one man on the plow and usually two others to manage the team. In countries where human labor is very cheap it probably still pays to use cattle; but in countries like the United States and Cuba, where farm wages are high, it is cheaper and more satisfactory to use horses and mules. At the South mules seem on the whole to stand farm labor better than horses. Where farming is carried on on a large scale and where the land is level and other conditions are favorable, steam power is coming to be utilized more and more for plowing and other farm work. Steam plows are of two general types: first, those where the gangs are drawn by locomobile engines which simply replace the animals and move round and round the field; and second, those where the gangs are attached to cables and are drawn back and forth across the field by a single stationary engine or by two which are moved slowly along its opposite sides. Recently the attempt is also being made with some success to adapt gasoline or alcohol motors such as are used for automobiles to agricultural purposes.

If a field is always plowed in the same manner, the continued turning of the furrows in one direction

tends to pile up the dirt around the borders and to hollow it out in the middle of the field, where the center or so-called "dead furrow" comes. Occasional back furrowing remedies this trouble. To back furrow it is necessary to begin plowing in the middle of the field and turn in the opposite from the usual direction so as to continuously turn the furrows toward the center. By using skill in laying out the lands for plowing and by back furrowing when necessary a field may be kept quite level or high places may be leveled down and low ones filled up, or if the land is low and wet, it may be gradually built up into narrow beds with open water furrows between them in such a way as to greatly improve the drainage. It is usually better to take long narrow lands rather than those that are short and nearly square as there will be much less time lost in turning.

Great care should always be taken to see that plows are so adjusted as to run level and even, and that they turn the soil to the desired depth. On sulky plows these adjustments are made by means of the various levers. On walking plows the depth is regulated by adjusting the clevises at the end of the beam by which the team is attached. The lower the point of attachment, the shallower the plow will run. Elevating the point of attachment correspondingly deepens the furrow. Shortening the traces or elevating them by adjusting the back bands will also serve to lessen the depth of the furrow. On many plows there is a secondary clevis by means of which the width of the furrow may be regulated. When the ground is in good

condition, a team can turn a wider furrow than when it is hard and dry. The skill of the plowman will be shown by the care with which he makes all these different adjustments and varies them to suit changing conditions.

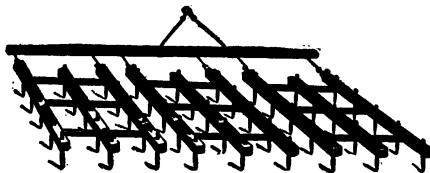
Harrowing.—In the preparation of the soil the harrow is of almost equal importance to the plow, but on most farms its use is not so well understood. The intelligence of a farmer can be very accurately gauged by the skill with which he uses this implement. In only too many cases the soil is turned up in great hard lumps by the plow and these are allowed to lie and bake for days in the sun before any attempt is made to break them to pieces with the harrow. In this condition the harrow can only drag the clods about or jump over them as if they were stones, and it is found impossible to put the land in fit condition for planting until after soaking rains. On lands that are intended for immediate planting the harrow should always quickly follow the plow. If the ground is moist enough to plow at all, the clods and lumps will be easily broken or cut to pieces by the harrow if it is used at once. The surface of the fine mellow earth so formed soon dries and forms a dust mulch which prevents the drying out of the lower layers, and so holds enough moisture in the soil to secure the prompt germination of the seed. The main use of the harrow is to put the soil in such a physical condition that it can best retain moisture for the use of the crop. If, for any reason, a field is not planted as soon as it is prepared, the harrow should be run over it again, to

freshen the surface just in advance of planting. This will kill many germinating weed seeds that would otherwise spring up in advance of the crop.

There are many kinds of harrows adapted to different purposes and to different conditions of the soil. The following include the more important types:—

The old-fashioned square or V harrow consists of a heavy wooden frame, made either in the form of a square or a V, carrying a number of strong square steel teeth that project downward six or eight inches. The team is hitched at one corner, and it is dragged back and forth, or round and round the field. It is a crude implement, but it is one of the best to use on rough, stumpy land, as the stout frame will slide around the stumps without injury.

The slant tooth, or smoothing harrow, carries more numerous smaller teeth, usually in a sectional iron frame so arranged that the teeth may be set at



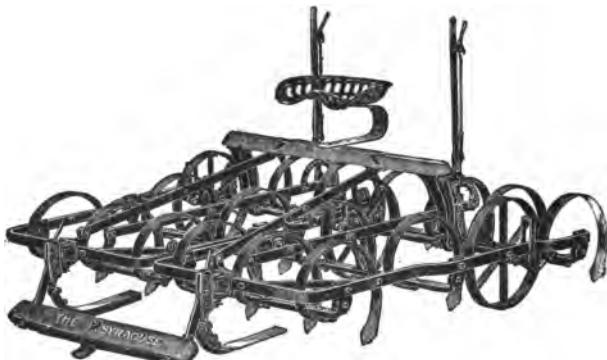
Smoothing Harrow.

any desired angle by means of levers. This is a very useful tool. It scarifies and levels the surface without dragging out buried grass and weeds. It is often used after other harrows in order to give the land a finishing touch in advance of planting. With the teeth set at an easy angle it can also be

run over the ground after the seed is planted, and, in the case of corn and some other crops, even after the plants are up, and it thus serves to give an efficient and very cheap first cultivation.

The acme harrow consists of gangs of narrow, knifelike, curved steel blades, arranged with their cutting edges downward and adjusted to cut deeper or shallower by means of levers. This is a riding harrow. It does much the same work as the smoothing harrow, but it stirs and levels the surface of the soil rather more effectively. It cannot be used after the crop is up.

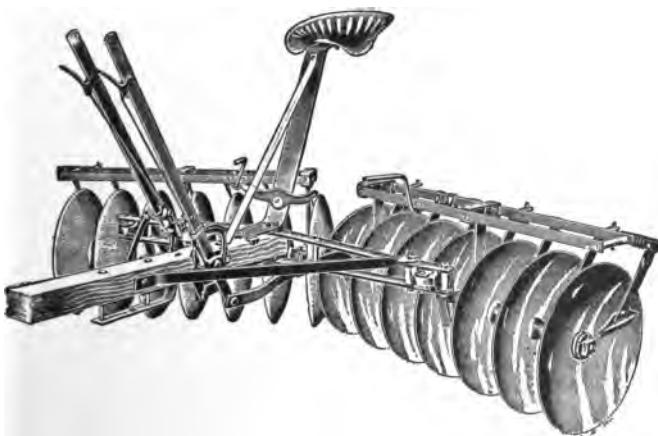
The spring-tooth harrow has teeth made of long coiled bands of tempered steel, so arranged that the



Spring-tooth Harrow.

free ends dig into the soil like little shovels. Their jerky, springy motion enables them to enter the ground easily, and they are very effective in fining it and tearing it to pieces. They are especially use-

ful in lightening and loosening the soil after it has been compacted by heavy rains. An objection to their use, under some circumstances, is that they tend to throw buried grass and weeds to the surface. At other times this is an advantage. These harrows can be used successfully on rough, rocky, and stumpy ground, since when one of the limber teeth encounters an obstruction, it straightens out and slips over



Disk Harrow.

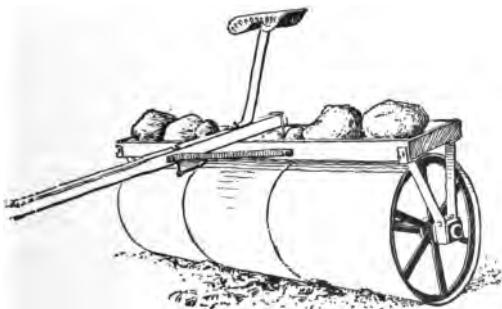
it, and then springs back into shape. These implements are made either as riding or walking harrows.

Disk harrows are similar in principle to disk plows, but the disks are smaller, usually twelve to sixteen inches in diameter, and a number of them are mounted side and side on one axle. In the usual form of the implement two such gangs of from four to eight disks each are mounted so that they

can be set by means of levers to work at any desired angle to each other. If the gangs are set straight, that is, with their axes in the same direction, the disks will simply cut lines in the soil, but it will not be moved and broken. The sharper the angle at which the gangs are set, the more the disks will push and turn the dirt, throwing it in each direction from the center. To keep the land level it is necessary to drive so as to lap half, that is, so that the outer end of one of the gangs, the second trip, will pass where the center of the machine passed the first trip. In this way the soil will be worked first out and then back, and it will be left in very fine condition. This is always a riding harrow. The disks may be solid or cut away in wide notches. The disk harrow will cut up sod, and cut and grind up clods, better than any of the others. In almost all cases it is the best implement to put immediately behind the plow. One should be included in the equipment of every farm where the land has been sufficiently cleared to admit of its use. It is an awkward implement to use among stumps and large rocks. In fact, every farm should be equipped with more than one kind of harrow. The disk should follow the plow, and on the same day that the land is plowed; but to secure a really good, fine seed bed, it is necessary on most soils to follow the disk with the acme, or the smoothing, harrow. This, as a rule, should be done just in advance of planting. If light rains have fallen between the two harrowings, so much the better, as the surface will pulverize better and the lower layers will be somewhat compacted so as

to hold moisture better. If, however, a heavy rain has fallen and the land is much compacted, it may be necessary to re-disk it, or to dig it up with the spring tooth.

Rolling and Dragging.—A roller is a heavy cylinder mounted so that it can be rolled over the land. It is used for crushing clods and also for compacting the soil when it has been left too loose and open by the plow. It requires good judgment to know when a roller can be profitably used. If harrowing has been properly done, there will be no large clods

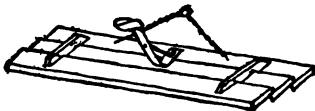


A Roller.

to crush, and the roller is simply used for firming and compacting the soil. In some kinds of soil if no rain falls for a considerable period after plowing, there is danger that all of the plowed soil may dry out since the air spaces are too large for the moisture to rise from below by capillarity. Seeds planted under these conditions would fail to germinate. Passing a heavy roller over such a field soon after it was plowed would press the particles closer

together so as to restore capillary action and the stirred soil would be moistened from the subsoil below, and seed would be much more likely to germinate promptly. The compacting of the surface, however, favors evaporation, and the danger now is, if the drought continues, that the reserve moisture of the subsoil will be all pumped up and evaporated so that the young plantlets will suffer. To avoid this trouble it is usually best, when it is found necessary to use the roller, to follow this implement with the smoothing harrow to break up the compacted surface and restore a dust mulch. Of course plowed land should never be rolled when it is wet. Grass land is sometimes rolled when quite wet in the early spring to settle plants into the ground that have been lifted by freezing or to bury small stones out of the way of the mowing machine.

A plank drag, or leveler, is sometimes used after harrowing instead of the roller. This crushes clods and fines and levels the surface even better than



A Plank Drag.

the roller and leaves it in nice condition for a seed bed. On most soils it is preferable to the roller. It is an inexpensive implement that can be made by any farmer out of a few pieces of two-inch plank.

Furrowing or Bedding.—The soil being now pre-

pared for planting by plowing and harrowing and if necessary rolling or dragging, the next proceeding will depend on the nature of the crop and the character of the soil. If crops are to be planted broadcast, the seed will now be sown and it will be harrowed in. No tillage is possible, as a rule, with broadcast crops, so that this completes the labor until the harvest. If small grain is to be drilled instead of broadcasted, the land is now ready for the drill. For most crops, that are to be planted in rows, like corn, no further preparation is necessary, but the seed drill is run over the level land, or a light furrow is opened and the seed dropped by hand. For cotton, however, and for most vegetable crops on wet lands the soil is bedded up before planting by throwing two furrows together and running the planter on top of the low ridge thus formed. If the beds are too high, they can be partially leveled with the drag.

For sugar cane, however, on well-drained lands and for many other crops in dry countries the practice is just the reverse. A deep furrow is opened with a double moldboard plow or lister, the seed is planted in the bottom of the furrow and is lightly covered, the planting furrow being gradually filled in by tillage as the crop grows. On light friable soils the preliminary plowing and harrowing is often dispensed with for such crops as corn and cotton, the listing furrow being opened or the bed thrown up with the soil in the condition left by the previous crop. This, of course, saves much labor, but it is not practicable on heavy refractory soils. If fertilizers are used, they should be applied so as to be incorporated

in the beds or be worked into the soil in the bottom of the planting furrow.

Tillage. — This term is employed for all those operations by which the soil is stirred about growing plants. The word "cultivation" is often used as the equivalent of tillage, but in reality it has a broader meaning and covers not only this, but all the other processes required in the production of crops. Tillage is beneficial and for most crops positively necessary for the following reasons. First, it kills weeds. This is its most obvious utility and unfortunately it is the only one that is understood by many farmers. All plants that come up of their own accord in cultivated fields or in grass lands are termed weeds. In fertile soils, especially if carelessly tilled, they usually spring up in great numbers. They are very harmful, especially when the crop is young and small, since they not only rob it of the needed plant food and soil moisture, but by their ranker growth they crowd and smother it by shutting out light and air. Killing weeds is thus an absolute necessity. Careful farmers will always see to it that all weeds are killed before they produce seed. In this way in the course of a few years their numbers can be very sensibly reduced.

While the killing of weeds is thus the most obvious necessity for tillage, it is by no means its only or perhaps its chief benefit. The roots of plants require air as well as moisture for their normal development. Tillage breaks the hard crusts formed on the surface of most soils after rains and allows the oxygen of the air to enter it freely and also provides

for the escape of the surplus carbonic acid that is constantly being formed in the soil from the decay of organic matter.

This free interchange of gases between the soil and the atmosphere is necessary, not only for the normal growth of roots, but for the carrying on of all those manifold biological activities already referred to on which the fertility of the soil so largely depends. Tillage, therefore, not only kills weeds and provides an abundant supply of oxygen to the roots, but it actively promotes nitrification and all those other complex chemical changes induced by the growth of bacteria by means of which vegetable matter and other potential plant foods in the soil become soluble and available for the growth of plants. This unfortunately is not an unmixed benefit. Soluble plant food that is not at once absorbed by the roots is in danger of being washed or leached away by the rains. This, in fact, is constantly taking place. The fact should never be lost sight of that while tillage is absolutely necessary for the production of good crops, it also rapidly depletes soil fertility. When land is constantly devoted to tilled crops, active measures must at the same time be taken for adding in some manner to its supply of vegetable matter and other plant foods, or its fertility will be rapidly exhausted. This is especially true of tropical or subtropical countries where these soil activities continue unchecked throughout the year.

Finally and perhaps most important of all, tillage aids materially in conserving the moisture of the soil during dry weather. The fertility of a soil

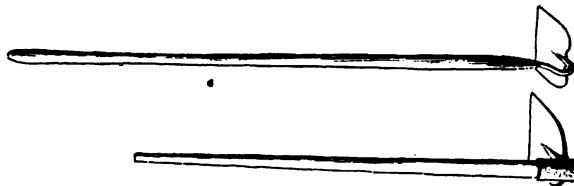
depends quite as much on its consistency and water-holding capacity as on its chemical composition. During and after a heavy rain there is, of course, a movement of the water downward through the soil. This movement is due to the force of gravity. Its amount and rapidity will depend on the character and fineness of the soil particles and on their arrangement. Water sinks much more readily into a loose mellow soil than into one that is hard and compact. Not all the water, however, that falls on a soil passes through it. The attraction of each soil particle is sufficiently strong to hold against the force of gravity a thin film of water covering its entire surface. The smaller the soil particles, the greater will be their aggregate surface and the greater, consequently, will be the amount of moisture so retained. When the rain ceases and the surplus water has settled into the lower levels, a counter upward movement of moisture begins. The surface particles of the soil lose their film of moisture by evaporation. The soil having been compacted by the rain, these particles are in close contact with those below and a portion of the film of water which surrounds these lower particles arises by what is called capillary attraction to replace the moisture lost by evaporation, just as the oil in a lamp wick rises to replace that which is consumed in the flame. These lower particles that have now become partially dried call in turn on those below and thus a capillary pumping process is set up that if unchecked, will, in time, return to the atmosphere all of the moisture thus held in suspension in the soil. If, however, a

cultivator be passed over the land, stirring the soil to the depth of a few inches, the soil particles will be torn apart so that this capillary pumping system is broken up and the dried particle can no longer reach down and help itself from the moisture film of its neighbor. The result is that the surface soil that has been stirred dries out very quickly, but this layer of loose dry soil acts as what is called a "dust mulch" and protects the lower undisturbed portion from drying, in just the same way that a mulch of straw or of coarse manure would effect the same object. The growth of our crops depends almost entirely on this film of moisture that is retained by the soil particles. The root hairs which develop in such immense numbers near the tips of the youngest rootlets appress themselves close to the soil particles and are able to absorb moisture from this film together with the small amount of soluble material which it has taken up from the soil. It is in this way, and in this way only, that plants are able to supply themselves with the necessary mineral food elements, and with the excessively important nitrates, and it is from these films only that the necessary moisture is obtained to maintain the turgidity of the cells, supply the large amount lost by transpiration, and provide for all the manifold activities of life. If the soil contains too much water, so that the spaces between the particles are filled with it instead of with air, these absorptive root hairs perish for want of oxygen. If the films lose too much water from surface evaporation, the root hairs can no longer absorb it in sufficient quantities, and growth

ceases or the plants may even wilt and finally die. We thus see the great importance of doing everything possible to provide, first, for drainage to prevent the soil from becoming water-logged and, second, for the conservation of moisture to prevent the drying up of these films of so-called hygrostatic moisture on which the growth of our crops so completely depends. Tillage is our most efficient means for accomplishing this latter purpose, since a mellow tilled soil takes in all the water that falls in a light rain, while much of it runs off from the surface of a hard soil and is lost; and the stirring of the surface after a rain largely prevents the loss of water by evaporation. It should be the general rule on every farm to stir the ground around growing crops as soon after every rain as it can be worked without injury. The man who waits for a crop of weeds to grow before he cultivates fails to secure the greatest benefit from his labor.

The above remarks do not apply with such force in those tropical countries where there is a well-marked rainy season, since the rainfall is sufficiently frequent and abundant to insure a constant supply of moisture for many months. Here on fertile, virgin lands enormous crops are produced without any pretense at tillage. Even here, however, tillage eventually becomes necessary in order to mellow and aërate the soil and as being the most economical means of killing weeds. When crops are to be grown during the dry season, it becomes absolutely indispensable, although unfortunately its importance does not seem as yet to be appreciated in those countries.

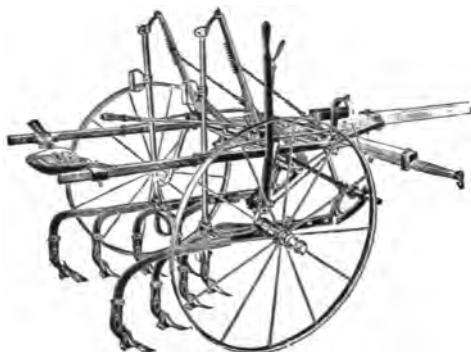
Implements of Tillage. — In small gardens the hoe and rake are the principal instruments for tillage. Various forms of wheel hoes are also used for tilling such field crops as sugar beets and onions that require to be worked while very small and which are planted in narrow rows. Labor with hand implements is, however, too expensive to be employed for most farm crops, and it is necessary to utilize



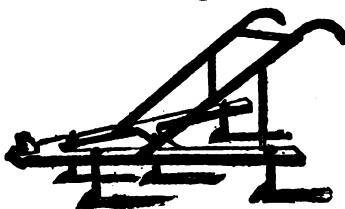
Goose-neck Hoe and Eye Hoe.

implements that are drawn by animals. In those tropical countries where labor is cheap the greater economy of using such implements is not yet fully understood, and many fields of tobacco and sugar cane may be seen that are still cultivated entirely by hand labor. The only places where this should be considered permissible is on new or very rough lands where implements drawn by animals cannot be used.

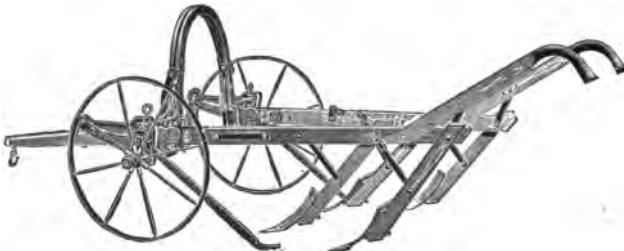
For such crops as corn, potatoes and sugar cane, when the land is in good condition and free from trash or obstructions, the best implement to use for the first cultivation is the smoothing harrow with the teeth set at an easy angle so that they will not



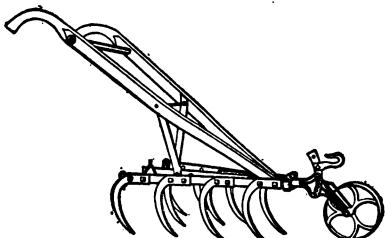
A Two-horse Riding Cultivator.



A One-horse Walking Cultivator.



A Two-horse Walking Cultivator.

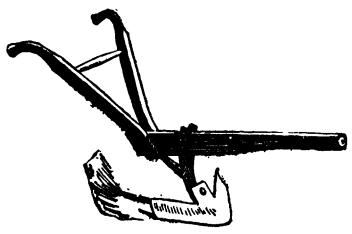


A One-horse Walking Cultivator.

dig too deeply into the soil. If used at the right stage of growth, it can be dragged over the young plantlets with almost no injury, while the surface of the soil will be left fine and mellow and the young weeds will be destroyed. This gives a very cheap and very effective tillage. By the time another working is needed the plants will be big enough so that the two-horse riding cultivator can be used. This implement straddles the row, and it carries two gangs of small shovels so arranged that they can be guided by the feet of the driver. The ground on both sides of the row is thoroughly stirred by one trip through the field, and enough fine dirt falls between the plants to cover and kill any small weeds that have found lodgment there. When this implement is properly used at frequent intervals, very little hoeing or other hand work will be required to keep a field clean of weeds and in good tilth until such a time as the crops shade the ground and tillage is no longer possible. Different sizes and shapes of shovels can be used on the gangs and they can be set so as to throw more or less dirt to the row. In some implements disk gangs may also be substituted for shovel gangs. This is the most universally useful implement for tillage and is adapted to a wide range of crops. There are, however, many others. A cheap walking cultivator drawn by one horse is very commonly used, especially on small farms. The usual form has five small shovels. The outer shovel on each side may be replaced by curved steel plates that scrape the dirt either from or toward the row. It is then called a horse hoe. The implement is usually made

so that it can be adjusted in width to suit narrow or wide rows, but it is usually necessary to run it twice in each middle in order to do thorough work. When cotton, tobacco, or vegetables are grown on a low bed or ridge, as is commonly the case in the South, a simple one-horse implement, known as a "heel sweep," is very much used. This consists of an ordinary single-shovel plow stock with a small "bull-tongue" shovel

to make it run steady in the ground, and bolted on under this point a narrow V-shaped band of steel about two or three inches wide. This blade varies in size according to the work to be done,



A Sweep.

from eight or ten to as much as twenty inches. When in use, the point is held in the ground at the base of the ridge or bed and the handles are leaned away from it enough so that one wing of the sweep will cut along about an inch under the surface of the bed. This mellows the surface and kills all weeds without tearing down the ridge. It is a very simple but very useful implement.

Formerly small turning plows were much used in tillage, but they are expensive in the matter of labor, as it takes several furrows to plow out a middle. They stir the ground too deeply, cutting many roots and allowing too large a portion of the soil to become dried out, and their use tends to ridge up the rows

more than is desirable except on very wet lands. Where there is no trouble on account of drainage, level cultivation is always to be preferred, since level land presents a less surface for evaporation than when it is thrown into sharp ridges.

All authorities now agree that while the preparation of the soil should be deep and thorough, tillage should be shallow and frequent, and that the surface should be left as nearly level as the necessity for surface drainage will permit.

Mulching.—In some special cases mulching with straw or other coarse litter may be resorted to instead of tillage for the purpose of conserving the soil moisture and preventing the growth of weeds. A mulch is often used about fruit trees and with small fruits, but as a rule it is too expensive for use with field crops. A permanent mulch has the disadvantage of tending to induce the formation of feeding rootlets near the surface of the ground, while tillage, on the contrary, tends to keep them down below the part of the soil that is usually stirred. What is in effect a temporary mulch is often cheaply provided by planting some quick-growing plant as a cover crop. Later when this cover crop is plowed into the soil, it furnishes the organic matter that is so constantly needed for maintaining its fertility. Tillage is usually necessary during the period when the crop is making its most rapid growth, but at all other times the land should as far as possible be protected by some cover crop to take up the elements of fertility rendered soluble by the tillage and which would otherwise be leached out from the soil and lost. The alternation

of short periods of tillage with cover crops is the best possible form of management for most agricultural soils.

IMPROVEMENT OF THE SOIL

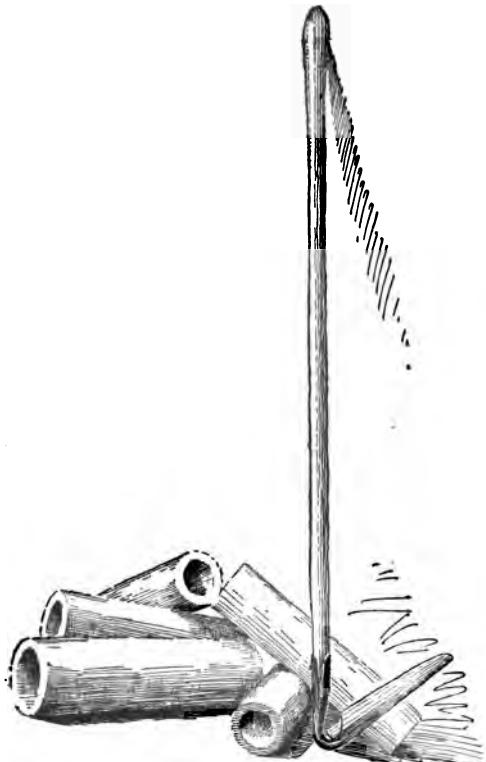
Some soils are in their natural condition exceedingly well fitted for the production of crops. Others require to be altered and improved in one or more directions before they can be made to yield profitable returns.

Drainage. — Some of the richest soils are low and flat, and in their natural condition crops are injured by too much water. A water-logged soil can never be productive. In such cases improvement by drainage becomes a first necessity. Drains are of two kinds, open ditches or surface drains and underdrains. The amount of ditching required to properly drain a piece of wet land will depend on many things. If the land is low and is flooded by water running down from above, a single ditch dug along the upper side to divert the surface water may be all that is necessary. If, however, the land is inclined to be boggy from water that rises up from below through the subsoil, deep ditches at comparatively frequent intervals will be required. Ditches should always be carefully laid out with a level so as to give them a gradual but uniform fall in order that they may carry off the water promptly. In laying out a system of ditches it is necessary to give careful consideration to the matter of securing a free outlet for the water. In very flat level countries it is sometimes necessary to dig large canals for a considerable distance in

order to secure a proper outlet for drainage ditches. If the slope of the land will permit, ditches should always be laid out parallel with each other as the land between them will be so much easier plowed and cultivated. The shape of the ditch will depend on the character of the soil and also on the kind of tool used in making it. In stiff soils a ditch with perpendicular banks will often stand very well, and this form is most economical when dug by hand. Other soils cave so badly that it is necessary to give the banks a very easy slant. Ditching by hand with spade and shovel is laborious and expensive. Where the nature of the soil will permit, shallow ditches can be quickly and cheaply made with the plow, followed by a V-shaped scraper made from one long and one short plank. The long plank acts as a rudder and holds the scraper straight in the furrow, while the short arm pushes the dirt out on to the bank. By giving two or three plowings and scrapings a fairly deep ditch may be dug. A road-grading machine drawn by six horses will, where the land is free from obstructions, do still cheaper and quicker work. When deeper canals are required, the bottom must be finished by pulling out the dirt with the steel scrapers used by railroad contractors.

Open ditches are very useful and often indispensable, especially for the larger central drains, and their first cost is much less than that of a proper system of underdrainage, but they are objectionable for many reasons. They take up much room, and it is difficult to keep the waste land along the banks free from noxious weeds. They prevent passing freely about the

fields, and when large, necessitate heavy expense for bridges. The annual cost for cleaning out and keeping in order is very considerable. For all these reasons



Draintile and Tile Hoe.

it is usually cheaper and more satisfactory in the long run to go to the expense of laying underdrains. Temporary underdrains are sometimes made by filling in the bottoms of ditches with poles or loose rocks and covering them, or by inverting a wooden gutter

in the bottom of the ditch and covering it. The only satisfactory underdrain, however, is made with the regular cylindrical draintile manufactured from brick clay. These tiles are made of any desired diameter, in pieces one foot long. A narrow ditch is dug, the bottom is carefully graded and shaped with a special implement known as a tile hoe, and the lengths of tile are laid in end to end and are carefully covered. The water enters between the joints, and when properly laid, the grade is such that the water flows evenly without depositing sediment to fill up the tile, and the work once well done is good for an almost indefinite period. The whole field may now be plowed and planted, and there are no unsightly ditch banks to breed troublesome weeds. The water, in working its way down through the soil to the drains, leaves little passages by which the air can enter so that underdrained soils are always better aërated and mellower than those with open drains. In consequence, they can also withstand droughts much better.

A competent drainage engineer should be consulted in laying out a system of underdrains, and the work of laying the tiles should not be undertaken by persons without instruction or experience. Tile drainage is as yet very little practiced in Southern countries. The conditions on many of the sugar-cane lands are such that it would unquestionably prove to be a profitable investment, and the time will doubtless come when it will be much more generally used.

Terracing. — While the South is thus somewhat backward in the matter of utilizing tile drainage, it

is here that we must look for the best practice in improving hillside lands by terracing. The cotton growers of the hilly uplands have adopted this system very widely and with great success to prevent the terrible loss from erosion or washing that always occurs when light, friable, hillside soils are carelessly tilled. Two methods to avoid loss from washing are adopted by the cotton farmer. The first is called circling the rows. Instead of laying out the rows in straight lines running up and down the hills, as is so often carelessly done, a row is first carefully laid out on a grade or contour line so that all parts of it shall be exactly on the same level. Such a row will circle in and out along an irregular hillside in a way that is sufficiently perplexing to one unaccustomed to this method. Other rows are then run parallel to this first one, and short ones are introduced, whenever necessary, to keep the rows strictly on contour lines. Such crooked rows look very peculiar and unbusinesslike to the farmer from the level prairies, and the system is open to the objection that cultivation is only possible in one direction; but when the laying out is properly done, it unquestionably does much to prevent the terrible loss from washing that is the bane of the hillside farmer.

This circling of the rows is regarded as a more or less temporary expedient. When it is intended to make a permanent improvement, the hillsides are laid out in terraces. To do this it is usual to start at the bottom of the hill and with a surveyor's level lay out a contour line, marking it with small stakes

at frequent intervals. A point three feet higher than the first terrace line is now measured with the level, and a second contour line is staked out as before. This process is continued until the entire field is staked out with contour lines, one located three feet vertically above the other. The spaces between these lines will, of course, vary greatly in width according to the steepness of the slope. Where the hills are steep, the terrace lines will run close together, and where the slope is gentle, they will be much farther apart. With a large two-horse turning plow a double-back furrow is now thrown against each line of stakes, throwing up as high a ridge as possible. This is intended to act as a dam to hold back all the water that falls on the terrace above and make it sink into the ground, instead of running rapidly down over the surface. This not only prevents washing, but tends to accumulate a store of moisture in the soil for the use of the crops. The land between the terrace lines is now plowed with a reversible hillside plow, so that all the furrows are turned downhill. The first row is now laid out along the terrace line and the others are located parallel with it, filling in the broader parts of the terraces with short rows on the upper side. The success of the system will depend on the skill with which the contour lines were laid out in the first place and the promptness with which any breaks in the terraces are repaired after unusually heavy rains. If the lines are not properly run, water will be sure to accumulate and break over at the lowest places. Badly laid out terraces do more harm than good. The continued

plowing with the hillside plow, year after year, constantly tends to build up the outer line of the terrace and cut down the inner one, so that ultimately the terrace becomes nearly level. This system, when carefully followed, has much to recommend it, and it should be much more widely adopted in all hilly regions. It is to be especially recommended for permanent plantings like orchards and vineyards. Coffee plantations are usually made in steep hill lands, and they should always be planted on some modification of this system.

On very heavy hillside soils, in regions where the rainfall is excessive and the question of surface drainage has to be considered, it is sometimes best to lay out the rows or the terrace lines with a slight but gradual fall, so as to slowly carry off the surplus water instead of trying to hold it and make it all sink into the ground. It is a difficult matter, however, to lay out the rows so that the water will run freely and still not run fast enough to wash. While the system is theoretically an ideal one, it seldom works satisfactorily in practice, and it should only be adopted after full consideration and usually after some preliminary trials. The amount of slope to give the rows will depend entirely on the nature of the soil, and the amount of the surplus rainfall.

Irrigation. — There are many regions where the soils are well adapted to agricultural purposes, but where the rainfall is insufficient or too irregularly distributed to admit of the production of crops. In fact it is a general rule that the richest lands are found in dry countries where they have not been

subjected to continued washing and leaching. All that is needed to make these lands exceedingly productive is the artificial application of water. This, when done on a considerable scale, is known as irrigation. The name would hardly be applied to the process of sprinkling small plots in a garden. Many of the most famous agricultural regions are entirely dependent on irrigation for the production of crops. It has been practiced for untold centuries in Egypt, India, and China, and was used by the Aztecs of Mexico long before the time of Columbus. At the present day it is largely practiced in all these countries, in Spain and Italy, in Hawaii, some of the West India islands, and on the west coast of Central and South America. Its most important recent development, however, is in the drier parts of the western United States, where great areas of what formerly appeared on the maps as "The Great American Desert" have been redeemed and brought into profitable production. The work of building reservoirs and of developing and controlling the water supply in the West has now been taken up by the national government and the development of irrigation farming is likely to be still more rapid in the future than it has been in the past.

At present irrigation is for the most part confined to what are known as the arid regions, where the rainfall is insufficient to produce crops. There are many other regions, however, where the rainfall is rather scanty, at least in what are known as dry years, or that are subject to long droughts that injure crops, where irrigation might be profitably employed

on special occasions to supplement the rainfall or with special crops like rice that need an abundant water supply at a certain period of growth. There is no doubt that in the future irrigation will be much more extensively practiced in what are known as humid regions.

In those parts of the tropics where there is a well-marked wet and dry season the rainfall is ample or even excessive for a part of the year, but is insufficient for the best growth of crops at other seasons. Since here the temperature conditions are suited to growth at all seasons the annual production could be greatly increased by supplying irrigation during the dry season. This has already been done in certain localities with very favorable results.

Water for irrigation purposes is obtained in various ways. The simplest and cheapest method, where this is possible, is to utilize the water of running streams. The water is diverted from the stream by means of a small dam at some point far enough up so that it is high enough to secure a free but not rapid flow in the canal which leads it to the land to be irrigated. The intake of the canal is so arranged that in time of flood only the usual amount is admitted, the surplus passing down the old channel. A gate is also provided by which all the water may be cut off from the canal when it is necessary to clean it or make repairs. From the main canal the water is distributed to the fields in ditches that are laid out according to the topography in such a way that the ditch always passes along the highest side of the field which is to be watered from it. The ditches are provided with

a system of gates so that the water can be run to or cut off from any part of the lands at pleasure. The length of the main canal and the cost of canal and ditches will, of course, depend on the topography of the region and on the character of the soil. Some soils dig easily and yet hold water in the ditches well. Here construction is cheap and easy. In rough broken countries it is often necessary to carry the canals or ditches over ravines or rocky places in flumes built of lumber. In other regions there are places where much of the water sinks into the ground and is lost. Here it is necessary to line the ditches with clay or sometimes even with cement. All this adds to the cost of construction.

Where no running streams are available, it is often possible to provide water for irrigation by building large dams across ravines in such a way as to make reservoirs for catching and holding the water from occasional rainstorms. The rain that falls in dry countries usually comes in the form of heavy showers, so that most of it runs off quickly from the hard, baked ground, forming temporary floods in the ravines and dry water courses. The catching and impounding of this storm water is more expensive than utilizing a running stream, but there are vast areas that can be irrigated in no other way, and there is no question but with the increase in value of agricultural lands more and more of these irrigation reservoirs will be built. In the case of running streams the building of storage reservoirs for holding the waste water largely increases the capacity of the stream for irrigation. Water from reservoirs is distributed

to the land by a system of canals and ditches with gates in the same way described above.

In some parts of the West considerable areas are now being irrigated from flowing artesian wells. Where artesian water can be obtained, it makes an ideal supply for irrigation. The irrigation farmer who holds lands under a ditch system is, to a certain extent, dependent on the water company who owns the ditches. He must take his turn with his neighbors and take and utilize the water when he can get it, not always when he would most like to have it. The fortunate owner of an artesian well is, however, independent. He can use his water how and when he pleases. It is usual to pipe the water from the well into a small reservoir located on the highest part of the farm. From here it is taken out in ditches or sometimes carried out in pipes, according to the way in which it is to be utilized.

There are many other regions where there is an abundant underground flow of water, but where the pressure is insufficient to cause it to rise to the surface. Here it is possible to sink wells and irrigate by pumping. This is being done more and more on the Western plains. Windmills are utilized very largely for pumping water for stock and for irrigating small plots, but the supply that can be obtained in this way can hardly be depended on for general farming. It is usually necessary to employ either gasoline or steam pumps. The cost of this, and, therefore, the extent to which irrigation by pumping can be utilized, depends on the two factors, the depth of the water and the cost of fuel. Low-lying lands

near rivers and lakes are often irrigated by pumping, where it is not feasible to take the water out in ditches. Where the distance to be lifted is small and fuel cheap, the powerful pumps now in use make this method of irrigation practicable on a large scale. Much of the rice land in western Louisiana and eastern Texas is irrigated in this manner. In irrigation by pumping the water may be run directly into the ditches, or it may first be stored in reservoirs. The latter is the more usual practice with small pumping plants.

In southern California and some other mountainous countries water for irrigation is obtained by drifts or tunnels dug back into the hills until some underground water channel is tapped. The water runs out of such a well as this by gravity and thus obviates the necessity for pumping. It is, of course, only under exceptional circumstances that this method can be employed, but such a "water mine" may be exceedingly valuable, for in arid regions it is the control of the water supply rather than the ownership of the land that carries the greatest value.

Whatever the source of the water, there are various methods of applying it to the land. Where the supply is abundant, especially with such broadcast crops as alfalfa and the small grains, the more usual method is by flooding the entire surface. In order to do this successfully the land must have been carefully prepared before planting and all the minor inequalities leveled down so as to allow of the even flow of the water. Temporary openings are made in the ditch bank and the water is allowed

to run first in one place and then in another until the entire field has been covered. A modification of this method consists in the throwing up of borders or ridges with the plow at right angles to the course of the ditch at intervals of three or four rods. These borders are smoothed up and pressed into shape with a V-shaped plank drag. The ground between the borders is dragged down level, and in irrigating the water is turned into one or two of these spaces and is allowed to run till it reaches the lower side of the field, when it is cut off and turned into the next spaces. This is a very practical method of irrigation and it is much used for quite a variety of crops. The distance to which the water can be run across such a field will depend on the nature of the soil and the amount of fall. With everything favorable a square forty-acre field can be irrigated from one head ditch, but in the majority of cases it is better to have ditches every forty or sometimes as close as every twenty rods. When the attempt is made to carry the water too far, it takes so long as to waste the time of the irrigator, and the land at the upper end next the ditch will be under water so long as to injure the crop.

In orchards and gardens, especially when the water supply is scanty, a system of basin irrigation is often followed. The land is divided into small areas and a border is put up on all sides of each area. The water is turned into the upper area until it has all the borders will hold. After it has stood long enough to soak in to the desired depth the border is cut and the water is allowed to run into the next

basin, this being repeated until the entire field has been flooded. It is possible in this way to wet the land very thoroughly, and it has advantages for certain purposes. It seems to be a favorite method with the small Mexican farmers in the Western states. The flooding of rice lands is managed in much the same way, except that for this crop the water is held on the land for a considerable period.

With crops that are grown in rows, what is called row or furrow irrigation is often practiced. This requires less water than flooding the entire surface. Sometimes, as is usually the case with sugar cane, the row is planted in the bottom of a deep furrow that afterward serves for irrigation. With more delicate plants the row is planted on a low ridge and the space between the rows serves as the irrigation furrow. If the rows are far apart, as in orchards and vineyards, an irrigation furrow is opened near the row on one or both sides. Furrow irrigation is usually only applied to permanent plantings of this kind, to vegetable or truck crops, and to sugar cane. When water is very scarce and expensive, it is sometimes brought to the ends of the rows in wooden troughs with holes and plugs so arranged that it can be run directly into the furrows as needed. This obviates the loss by seepage in the ditches, but it is, of course, more expensive. In the tobacco fields in some parts of Cuba water is pumped from deep wells and is carried to different parts of the field in iron pipes, being then distributed to the plants in buckets by hand. This method is not only expensive but inefficient.

All of the above are forms of what is called surface irrigation. They are all open to the objection that they pack the surface of the soil, leaving it hard and in a condition to bake badly unless each irrigation is followed by tillage. Excepting where the land is very nearly level there will also be loss from surface washing. These troubles can be obviated and better results can be obtained by what is known as subirrigation. In this system the water is distributed under the surface by means of porous pipes. It permeates the subsoil and keeps it moist without interfering with the condition of tilth of the surface. Lines of draintile are sometimes so arranged that by closing the outlets and flooding them they can serve for subirrigation during dry weather, and by opening them again their action as underdrains can be restored in case of heavy rains. Subirrigation gives very fine results in greenhouses and on ornamental grounds where there is no objection to expense, but it is too costly for ordinary farm operations, and we must rely on frequent tillage to obviate the bad effects of surface applications of water. With all crops that permit it tillage should invariably follow an irrigation as soon as the land becomes dry enough. This prevents baking and the formation of a hard crust; it aërates the soil and, by the formation of a dust mulch, preserves the moisture and renders future irrigations necessary at much less frequent intervals. The greatest temptation to the irrigation farmer is to rely too much on water and too little on tillage.

The overabundant use of water should always be avoided, especially in arid regions. Where there is

little rainfall to wash out soluble salts, they gradually accumulate, especially in those places where water stands and evaporates so that a thick alkaline incrustation is often formed on the surface. The alternate soaking and surface drying of the soil tends to pump up the soluble salts from the subsoil and concentrate them near the surface. Even where the water used is in itself free from alkali, continued careless irrigation will, in many parts of the West, so bring the salts to the surface as to prevent the production of crops. Thousands of acres of valuable lands have already been ruined in this way. An absolute remedy for this trouble is, however, to be found in proper drainage. A system of underdrainage, which will carry off the surplus water from below instead of allowing it to evaporate from the surface, will not only prevent the undue accumulation of salts in the upper layers, but it will serve to redeem lands that are naturally too alkaline for cultivation by washing down the alkali and carrying it off in the drainage water. There are immense areas of land in the West that are now absolutely worthless on account of an excess of alkali that could be redeemed and made extremely fertile by a combination of irrigation and underdrainage. Even without underdrainage the digging of deep surface drains at such places as will serve to quickly carry off the surplus irrigation water from the bottom of the fields instead of allowing it to stand and evaporate in the low places will do much to obviate what is really a very grave danger for the irrigation farmer in many parts of the arid regions. In fact irrigation should

never be employed in any country without making full provision in some way for the carrying off of the surplus water.

Improving the Soil Chemically. — In the previous paragraphs various means have been discussed for improving the physical condition of the soil. It now remains to consider how its chemical condition may be improved.

Liming. — When soils are lacking in lime, the transformation of vegetable matter does not proceed properly and an acid condition of the soil is induced that is very detrimental to certain crops, especially to clover and many other of the legumes. Corn and potatoes, on the other hand, do not mind a slightly acid soil. In fact it is an advantage for the latter crop, since it partially prevents the growth of the scab fungus, and the potatoes are smoother. Whether or not a given soil will be benefited by the application of lime can usually be easily determined by mixing a little of it to a thin paste with water and inserting bits of blue litmus paper. If after standing a few minutes the paper turns red or reddish, an acid condition and the need of lime is indicated. As a rule, sandy lands are more likely to be deficient in lime than clays. In the case of very stiff, refractory clays, however, applications of lime are sometimes useful, even if there is no acid reaction, since the lime tends to make them more friable and to render the mineral food elements more soluble and available. Recently drained muck and swamp lands too are usually sour and are much benefited by lime. On sandy lands, where a large amount of vegetation is plowed under as

a green manure, it is often best to apply lime to avoid inducing an acid condition. On the other hand, the overapplication of lime is sometimes very injurious. As is said, it burns the life out of the soil by rendering the elements of fertility too quickly and completely soluble, so that they are leached out and lost. Some soils, too, it renders more liable to crust and bake after rains. Lime should never be applied unless there is clear evidence that it is needed, and good judgment will be required to determine how much to use, since this will depend entirely on the actual condition of the field to which it is to be applied. As a rule when lime is needed, it is best to make one pretty thorough application and then add no more for four or five years rather than to add small dressings annually. It is best, too, to apply it as long as possible in advance of planting the crop so that it may have time to lose some of its caustic action and become more thoroughly incorporated with the soil. Lime is usually applied in the form of the hydroxide; that is to say, as slacked lime. This is the best form in which to use it where it is desired to quickly correct acidity or for the mellowing of intractable clays. For the permanent improvement of sandy lands, however, especially if used in large quantities, the carbonate in the form of finely ground limestone or shells is safer and will give much more permanent results.

Lime, in the form of the sulphate or land plaster, is often applied with good results, especially on clover. It should always be remembered, however, that lime applied in any form acts as an alterative or stimulant and not as a true food, and that unless active measures

are taken at the same time for increasing the food supply its use will tend to give temporarily increased crops at the expense of permanent fertility. In other words, as has been so forcibly said, if used alone, it tends to enrich the fathers, but to impoverish the sons.

Manuring. — This general term is applied to all those processes by which plant food is added to the soil for the purpose of maintaining or increasing its fertility. Some soils are naturally so deep and fertile that they may be cultivated continuously for many years without diminished productiveness, but even the richest will in time show signs of exhaustion if no plant food is returned to them. The problem of manuring is, therefore, one of the most important that can engage the attention of the farmer. The only exception to this statement is to be found in those few favored localities, like the Nile Valley, where the overflow from some great river brings down annually rich deposits from the washings of the lands near its source.

Stable Manure. — This is one of the most widely used and important substances for enriching the soil. It consists of the solid and liquid excrement of domestic animals mixed with more or less straw or other litter that has been used as bedding in the stables. It is more widely useful than any other fertilizing material and can be used to advantage on nearly all crops. It not only supplies all three of the useful chemical elements,—nitrogen, phosphorus, and potash in some quantity,—but it adds a large amount of easily fermentable organic matter to the soil and thus improves its mechanical condition. If

an abundant supply could always be had at a reasonable cost, there would be comparatively little need for other fertilizers. It is only on those farms, however, where the feeding of live stock is the principal industry that it can be produced in sufficient quantity to fully supply the need for maintaining fertility. A considerable amount can, of course, be obtained in towns and cities, but the expense of transporting it back to the farms becomes a considerable item, and the same amount of benefit can often be obtained more cheaply by other means. In every case, however, all the stable manure produced on the farm, be it much or little, should be carefully saved and utilized. On only too many farms, especially in new countries, this important matter is grossly neglected, and the manure is either wasted entirely or it is handled so carelessly that half of its value is lost. If not carried at once to the field when taken from the stable, it should be piled under some rough shed, where it will be at least partially protected from the rain. If it is where it will be tramped and compacted by cattle, or worked over by hogs, so much the better. If large quantities are thrown out at once, it should be thoroughly wet down to avoid a kind of mold known as fire-fanging. Thin layers of earth spread over the growing pile from time to time are also useful for absorbing the ammonia that escapes as fermentation progresses. Some farmers construct expensive cemented ditches or cellars in which to store manure, but this is not necessary. All that is needed is that it be sheltered from washing rains, and that care be taken to keep the piles compact and moist enough to prevent fire-

fanging. Such manure piles should be forked over at intervals in order to quickly get them into the best condition.

On grass lands, and sometimes to form a mulch about orchard trees, manure is applied as a top dressing. This, however, is rather wasteful, as part of the ammonia is likely to be dissipated in the atmosphere and a considerable value is likely to be lost by washing rains. Where possible, it is much better to plow it into the land. If the manure has been piled so that it is well rotted, this may be done at any time; preferably just in advance of planting the seed. Large quantities of unrotted manure, however, plowed into the land at this time are likely to do harm by rendering the soil too open and causing the crop to suffer from drought, unless rains are very abundant. When fresh manure from the stables can be plowed into the ground long enough in advance of planting, so that it has time to become partially decomposed, and the soil has been settled by a few heavy rains, the results are eminently satisfactory. In fact, when possible, this is the best way to utilize stable manure, since there is no loss in fermentation and no extra expense in rehandling. Instead of taking the manure from the stables daily, if box stalls can be provided for the animals and there is plenty of material for bedding, it may be allowed to accumulate in the stalls until such time as a field is ready for plowing, when it can be hauled direct to the field. The tramping of the animals in the stalls keeps it compacted and in good condition for a long period. Theoretically this method is more or less objectionable as being unhy-

gienic for the animals, and it certainly could not be recommended for dairy cattle ; but for fattening cattle and horses it has many practical advantages, provided always that the stables are dry and that enough bedding and other absorbents are used to keep them from becoming offensive.

Green Manures. — Since on most farms the supply of stable manure is entirely insufficient to replace the organic matter that is annually oxydized and destroyed in the soil through the influence of tillage, it becomes of the utmost importance to find some other means of supplying this deficiency. The important rôle played by decaying organic matter in the soil has already been touched upon, and it has been stated that its fertility can in many cases be gauged by the amount of organic matter which it contains. The problem should be constantly in the mind of every farmer as to how he can best keep his lands supplied with this ever-needed ingredient. In Southern countries, as has also been pointed out, this need is even greater than at the North, since here those fermentative changes by which the organic matter is oxydized and destroyed are going on uninterruptedly throughout the year. The easiest and cheapest way in which to supply this much-needed organic material is obviously to plow in and incorporate with the soil some part at least of the vegetation that is annually produced on it. This process is called green manuring, meaning the manuring with green plants. Its importance in farm economy cannot be overestimated. Fortunately at the South, where it is most needed, it is most feasible and practical, for the long growing season gives

time for growing one or more crops for sale and at least one crop every year for enriching the soil.

Any kind of fermentable vegetable matter is useful when incorporated in the soil. The stalks, straw, or other unused portions of all crops should be left in the field to be plowed under. Even unsightly weeds will have their usefulness if plowed into the land. Grasses of all kinds are also useful. The richness of well-rotted sod land is proverbial. Crops of the small grains like rye or oats or of fodder corn plowed into the land are also helpful. In the Southern states cotton and corn land should when possible be seeded down to winter oats or rye in the fall, since these crops prevent washing during the heavy winter rains and when plowed down in the spring add considerably to the fertility of the soil. All such green crops are beneficial, however, only for the organic matter which they contain and their consequent effect on the mechanical and biological condition of the soil. They add no important chemical elements, since all the nitrogen, phosphoric acid, and potash they contain was taken directly from the soil, and they, therefore, only return what they have already taken. The marvelous power has already been mentioned possessed by plants belonging to the *Leguminosæ*, of seizing and fixing the atmospheric nitrogen through the agency of the tubercle-forming bacteria that dwell in their roots. This overshadowingly important fact indicates clearly that some leguminous crop should if possible always be chosen for green manuring. A well-grown crop of clover, cowpeas, velvet beans, or beggar weed, turned into the soil, adds as much nitrogen as would be con-

tained in a heavy application of stable manure, and its effect on the improvement of the soil is fully as great. In planting one of these crops for soil improvement we can well say that we are growing a crop of stable manure, since its effect on the soil is almost identical. In one important respect it is, in fact, markedly superior. In only too many cases stable manure is the means of introducing the seeds of many noxious weeds and grasses. Crops of these legumes, however, occupy the land so closely that they smother and kill the weeds and are thus a considerable factor in subduing and eradicating them.

At the North red clover (*Trifolium pratense*) is the legume almost universally depended on for soil-improving purposes. It is also an exceedingly valuable forage and occupies a prominent place in the crop rotation adopted by all good farmers. It usually occupies the land for at least two years. Unfortunately it does not succeed well at the South and need not be considered in the region for which this work is especially written.

Crimson clover (*Trifolium incarnatum*) is an annual plant and, therefore, must be resown every year. It grows best during the cooler part of the year. It is well adapted to many of the soils of the Southern states, and where it can be made to succeed it is a very useful winter cover crop, especially for orchards and for cotton lands. The young plants are quite delicate and the land must be put in a condition of perfect tilth before the planting, in order to obtain a stand. It can be planted from August to October. It makes fine hay if cut when in bloom, and the crop

can be harvested in time to put in a late crop of cotton. The roots and stubble alone will add much to the fertility of the soil, but, of course, its

full benefit as a manure is only obtained when the entire crop is plowed under. As the clovers are not generally grown at the South most Southern soils do not contain the kind of bacteria that form tubercles on clover roots. To succeed with this crop, therefore, it is necessary in most instances to resort to what is known as soil inoculation, in order to provide these bacteria artificially. Two methods of soil inoculation are more or less in practical use. The first consists in taking a quantity of soil from a field where clover of some kind has already been grown successfully and sowing it with the seed. As much as a ton of soil per acre should be used to be sure of securing the desired result. In the second method the seeds are wet with a nutritive solution to which a pure culture of the desired bacterium has been added some hours previously.



Crimson Clover.

The infected seed is planted and quickly covered while still moist. Various methods have been devised for safely transporting and distributing pure cultures of these useful organisms, but none of them have as yet proved fully satisfactory in practice. The one adopted by the United States Department of Agriculture and most in use at the present time consists in saturating portions of absorbent cotton with fresh cultures of the bacteria and then quickly drying them. If the dried cotton is now securely wrapped to prevent it from again absorbing moisture, the culture will retain its vitality for a considerable period of time, and the packets of dried cultures may be safely shipped through the mails. If, however, the culture is exposed to alternate moisture and dryness, it soon dies. For use the bits of cotton with the dried culture are dropped into a bucket of water containing a prescribed portion of nutrient salts. In a few hours the liquid becomes turbid from the growth of the organisms, and it is now ready for moistening the seed. These dried cultures can be obtained commercially from most of the larger seedsmen, and while their use is often attended with failure, it is well worth making repeated efforts to get this and the next-mentioned crop established in new localities. The effect of a successful inoculation is sometimes little short of miraculous, the plants growing with the greatest vigor and producing a crop at the rate of one and a half or two tons of hay per acre, while on adjoining uninoculated plots the plants soon turn yellow and stop growing when only a few inches high. Such an experiment has to

be seen to be either believed or appreciated. Of course no such striking result follows inoculation on soils where clover of any kind has been already grown and where the soil is consequently supplied with the clover organism. Crimson clover will not be likely to succeed in any part of the tropics.



Hairy Vetch.

The hairy vetch (*Vicia villosa*) is another winter-growing legume that is of great importance for the Southern states, and it deserves to be much more widely cultivated. It should be planted in the late summer or fall, like the crimson clover, but as the seeds are large and the young plants much more vigorous it does not require such careful preparation of the

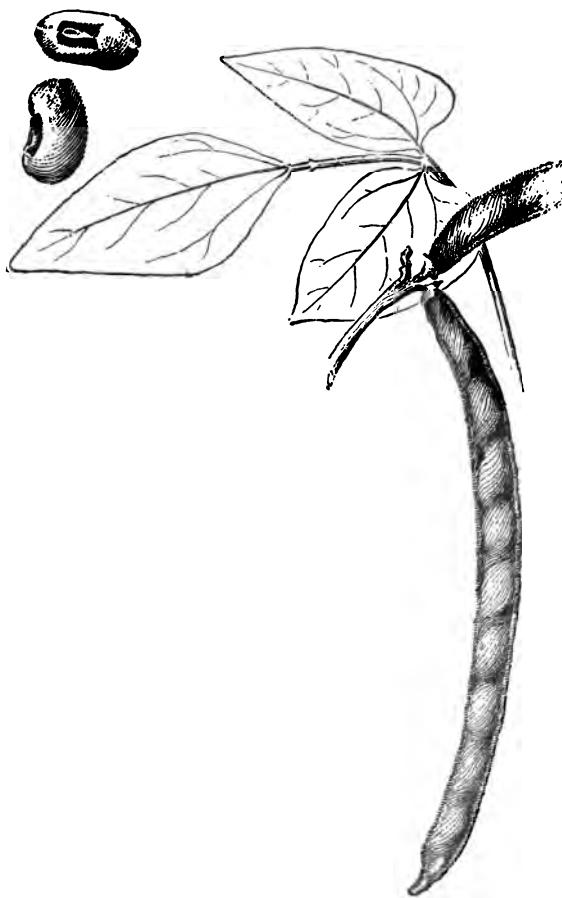
soil. It produces an even better forage than crimson clover and as a soil-improving plant it is unexcelled. The only objection to it is the rather high cost of seed. When once established on the land it, however, reseeds itself freely. The seeds lie dormant during the summer, but germinate on the approach of cool weather in the fall. As a cover crop for orchards it is exceedingly valuable, since it covers the ground and prevents washing during the winter and furnishes much valuable fertilizing material, while at the same time allowing of free cultivation during the summer. It can also be utilized in corn and cotton fields, but it is necessary that these crops be planted a little late in order to allow for the ripening of the vetch seed in the spring. Soil inoculation is usually necessary with vetch, since most Southern soils do not contain its specific organism. Unfortunately the tubercle bacteria of vetch and clover are not identical, and the fact that the soil is inoculated for the one will not help it to grow the other. The pods of vetch are often freely attacked by the cotton-boll worm and this has prevented the profitable production of vetch seed in the Southern states. It will be seen that crimson clover and vetch fill much the same part in the farm economy, each being winter-growing legumes of about equal value as cover crops, as forage, and for green manuring. The vetch, however, will thrive under a wider range of soil conditions and has the great advantage of reseeding the land. There is no more rapid and effective method of improving exhausted Southern lands than by planting vetch in the fall and following this with corn and cowpeas in the

summer. The corn crop, together with the pasturage afforded by the peas in the fall and the vetch in early spring, will more than repay the phosphate and labor required. A very few years of this treatment will restore the poorest, most exhausted fields and make them as productive as the best virgin lands.

The spring vetch (*Vicia sativa*) grows in much the same way as the hairy vetch. It, too, is a useful plant, but it does not make as heavy a mass of vegetation as the other. The vetches are not well adapted to the tropics.

The cowpea (*Vigna Catjang*¹) is, without doubt, the one most important legume for Southern agriculture. It has often been called the clover of the South, since it plays the same leading rôle here that red clover does at the North. It is a rank-growing annual, completing its growth in about three months. Being of tropical origin, it delights in hot weather and does not succeed well during the cooler months. Its short growing season makes it possible to grow it as a manurial crop at times when the land would otherwise be unoccupied, as, for instance, after a crop of winter oats or rye or after an early spring crop of vegetables. It is most widely used, however, to plant between the rows of corn at the time of the last cultivation when the crop is being laid by. It can in like manner be very profitably used on cane plantations to sow between the cane as a cover crop at the beginning of the rainy season. The peas

¹ Wight (U. S. Dept. of Agric., Bureau of Plant Industry, Bull. 102) shows that most of the varieties of cowpeas should be referred to *Vigna unguiculata* rather than to *V. Catjang*.



The Cowpea.

can be sown broadcast, using from three pecks to three bushels of seed per acre. It is more usual, however, to plant in drills about three feet apart. This only requires about half as much seed and allows of giving one or two cultivations. If supplied with potash and phosphoric acid, they will make a rank growth even on very poor lands. The use of a fertilizer that supplies these elements is often required to secure the best results. They are very efficient as nitrogen gatherers and thus serve to build up and enrich the soil very rapidly. Practically all soils at the South and in the adjacent tropics are plentifully supplied with the appropriate tubercle-forming bacteria for this plant, so that soil inoculation is seldom necessary. There are many varieties of cowpeas. These differ not only in the color and size of the seed, but in time of maturity and habit of growth. The whippoorwill, or speckled pea, matures very early and has an erect, almost bushlike habit of growth. It yields a large amount of seed, but produces less leaves and vines than some of the others. It can be planted farther north than the other kinds, maturing well in Kansas, central Illinois, and Delaware. It is also particularly useful when the land can only be occupied for a short time, and from its erect habit of growth it is easily cut and handled in making hay. The iron pea, unlike the whippoorwill, produces a large amount of vines and leaves, but usually ripens a less amount of seed. It remains green longer than any of the others and is thought to be more resistant to certain diseases. At the South, where the season is long, it is one of the

best kinds to plant for soil-improving purposes. It is particularly adapted to conditions in Cuba. The wonderful pea combines to some extent the qualities of the other two, producing more vines than the whippoorwill and more seed than the iron. It is a good general-purpose pea over a wide territory. Cowpeas will thrive on a great variety of soils, but do best on well-drained clays or sandy loams. They are easily injured by standing water and do not, as a rule, do well on very light shifting sands. On these lighter soils especially they are subject to two rather serious diseases. They are attacked by "wilt" (*Neocosmospora*), a fungous disease that enters the plant through the roots, and are also subject to the nematode root knot (*Heterodera*), which is so common a pest in sandy Southern soil. No remedy for these troubles is known, and it becomes necessary to abandon the planting of peas on lands badly infested by them. The iron pea, it is claimed, is partially immune to both of these troubles.

It is sometimes a question how best to utilize a crop of peas. If cut as the first pods are maturing and properly cured, they make a hay fully equal to the best clover hay. As with clover most of the curing should be done in the windrow and shock. The leaves will fall badly if the hay is allowed to lie too long fully exposed to the sun. Where enough stock is kept to eat the hay, this is undoubtedly the best use to which the cowpea crop can be put, since nearly all of its manurial value is recovered in the droppings, and its very considerable food value is also utilized. Even when the hay is cut and sold, repeated careful experi-

ments demonstrate that enough nitrogen remains in the roots, stubble, and fallen leaves to very materially increase the following crop, whatever it may be, that occupies the field. If the hay cannot be profitably utilized, it may be possible to allow the crop to ripen, gather the pods, and then plow under the vines. This plan is often followed. The peas and pods make excellent feed for horses, mules, or hogs, and the shelled peas have a considerable commercial value as human food and for seed. The unripe pods, too, may be picked and eaten like string beans. Farmers sometimes save the expense of gathering the crop by turning in the hogs as the peas begin to ripen. Nowhere will hogs make a more thrifty, rapid growth than when having the range of a pea field. Even if it is impossible to utilize the crop in any of the above ways, the Southern farmer should always plan to plant every acre of his land, that it is possible, in cowpeas every year, for in no other way can he build up its fertility so cheaply and so rapidly. It has been said that a man is a benefactor who causes two blades of grass to grow instead of one. If this saying had referred to cowpeas instead, it would have carried a much greater truth.

Velvet Bean (*Mucuna utilis*).—This is another rank-growing, tropical, annual, leguminous vine that is exceedingly useful as a soil-improving and cover crop in the far South and in the tropics. It requires rather a long season of warm weather and does not succeed well much north of central Alabama and Mississippi. It will flourish on any well-drained soil, even growing on the lightest sands if they con-

tain a sufficient amount of phosphoric acid and potash. What first brought it into prominence was the fact that it grew so vigorously on the light, sandy soils of Florida, where the cowpea failed on account of the attacks of nematodes. The velvet bean is per-



Velvet Bean, leaf and flowers.

fectly immune to this pest. It has been widely used in Florida as a cover crop in orange orchards during the summer rainy season, the usual practice there being to cultivate during the dry season of winter and shade the ground with some green crop during the summer. The velvet bean seems admirably

adapted for this purpose, accumulating vast quantities of nitrogen and leaves an immense deposit of vegetable matter. It is necessary, however, to constantly keep it cut away from the trees or it would soon climb up and smother them. The climbing power of this vine



Velvet Bean, fruits.

is something remarkable. An instance is known to the writer where beans planted at the foot of a fifty-foot windmill tower climbed to the top by fall and had to be cut down to prevent clogging the wheel. The velvet bean does not produce flowers and fruit until very late in the fall. In Florida a large crop

of seed is secured, but they cannot be depended upon to ripen seed much farther north.

For the latitude where it succeeds the velvet bean must be considered as a formidable competitor with the cowpea for first place as a soil-improving crop. It cannot, however, be used interculturally among other crops as can the cowpeas, but must occupy the ground alone. When land can be given up to a soil-improving crop for from four to five months during the summer, no other crop will produce such satisfactory results in the way of securing nitrogen, smothering foul weeds, and adding humus to the soil. It thus adapts itself perfectly to the needs of winter truck growers in southern Florida and the tropics and to use in Cuban tobacco fields, since in Cuba tobacco is strictly a winter crop and the land, as a rule, lies idle during the summer.

It is also an invaluable plant in preparing the land for permanent crops like orchards or sugar cane.

What clover is to agriculture of the North and the cowpea is to the cotton belt, the velvet bean is destined to be for the tropics, where the need for a much greater use of soil-improving plants is so imperative.

Like the cowpea, velvet beans may be sown broadcast or planted in drills; in nearly all cases the latter is preferable since one or two cultivations give them a chance to get ahead of weeds and grass. When they once begin to run, no further attention is needed, since they quickly climb up and by their weight bend over and drag down any chance weed that happens to spring up among them. They will

cover and completely bury, and in this way almost exterminate, that most dreaded of Southern weeds—Johnson grass.

When green, velvet bean vines are not at first particularly relished by stock, but a taste is soon acquired for them; the partially ripened pods in the fall, however, furnish very rich pasturage. The vines, if cut and cured into hay, are eaten readily and are very nutritious, but they are so long and tangled that they are difficult to cut and handle.

It is often found quite difficult to properly plow under and incorporate with the soil the dense mass of vegetation produced by a crop of velvet beans.

By first passing a roller over the field, or a log drag, to flatten them down, a sharp disk plow will bury them very satisfactorily, and the vines rot quickly in the ground and in the course of a month will have so far disappeared as not to interfere with cultivation. On heavy lands the best results will be secured by cross plowing after three or four weeks. On lighter soils this second plowing will not be needed, and the land can be put in perfect tilth by the use of a disk harrow. There is considerable prejudice on the part of some against incorporating so large a mass of green vegetation with a light, sandy soil for fear of creating an acid condition; this danger is in most cases more fancied than real, though many people on sandy land prefer to allow the vines to die and dry out on the surface before plowing them under; this will always be the better plan when the land is not going to be immediately utilized for planting some crop.

Florida Beggar Weed (*Desmodium molle*).—This is an erect-growing annual plant. It is grown quite extensively during the summer as a cover crop for orange orchards in Florida. When once established,



Florida Beggar Weed.

it reseeds itself and comes up at the beginning of the summer rains, even when the land has been thoroughly cultivated during the winter and spring. It could also doubtless be utilized as a cover crop in cane fields. Beggar weed thrives on the thinnest, sandiest soils as well as on those of better quality. It is an

efficient nitrogen gatherer, furnishes much nutritious pasturage, and if planted thick and cut young, it makes good hay. The stems, however, get hard and woody with age. It should always be used in orchards on soils where cowpeas do not thrive, and for orchard purposes it has the considerable advantage of reseeding itself. It is sown broadcast, using about eight quarts per acre. It thrives well in the tropics, where it is an indigenous weed.

Other Legumes for Green Manuring.—There are many other leguminous plants that are sometimes used for green manuring. Of these Japan clover, bur clover, alfalfa, and the peanut will be discussed under forage plants. On the rotten limestone prairies of Alabama and Mississippi sweet clover (*Melilotus alba*) has proved to be the most useful of all legumes. Its long taproots penetrate the hard subsoil, thus making it permeable and greatly improving its mechanical condition, in addition to adding to its store of nitrogen. At the North this plant is considered a pestiferous weed. In some of the West India islands indigo (*Indigofera anil*) has been more or less used as a green manure. Leguminous trees of various kinds are usually chosen by coffee and cacao planters to use as shade trees among their crops. The trees as well as the herbaceous plants belonging to the *Leguminosæ* produce root tubercles, and they thus add nitrogen to the soil at the same time that they shade the trees. This family is very largely represented in the natural flora of all tropical countries, the number of species found far exceeding those of temperate latitudes. Very many of them

possess habits of growth in a wild state that make a careful study of their cultural characteristics and possibilities exceedingly desirable. It is altogether probable that in the future many more of them will be utilized for soil-improving purposes than at present. As has already been pointed out, the subject of green manuring is of great importance in the tropics where the stock of vegetable matter in the soil is so quickly destroyed, but it is here that the subject has attracted least attention and its possibilities for good are only beginning to be realized.

Commercial Fertilizers.— While the subject of green manuring with leguminous crops is of the utmost importance to Southern agriculture, and while it is possible by this means alone to keep the soil in good mechanical condition, and to supply it with a large amount of nitrogen, it does not add to the total quantity of potassium and phosphoric acid, those other equally important food elements. With even the richest soils these will at length become exhausted, and it will be necessary to supply them in the form of commercial or, as they are often called, chemical fertilizers. Immense quantities of these fertilizers are sold annually in the South, and in only too many cases farmers have come to depend on them exclusively as the means of increasing their crops. This is extremely unwise. In the first place, it is poor economy. It is always unwise to buy that which can be produced cheaper at home. In the second place, soils manured year after year with only commercial fertilizers soon lose their vegetable matter, become difficult to work, and suffer excessively

from drought. Commercial fertilizers are really indispensable in modern agriculture and when used appropriately they are very profitable, but as a general rule they should only be used to supplement, not to replace, stable and green manures. It should never be forgotten that vegetable matter is always necessary in order to maintain the soil in a good mechanical condition and that this is fully as important as chemical composition in the production of crops.

Commercial fertilizers are valuable, generally speaking, only for the nitrogen, phosphoric acid, and potash which they contain. If a fertilizer contains all three of these substances, it is said to be a complete fertilizer. If one or more of them is lacking, it is called an incomplete fertilizer. Most farmers make the mistake of valuing fertilizers according to the price per ton. This is very misleading, and means nothing, unless the price per ton is considered with reference to composition; that is, to the number of pounds of each of these substances that the ton of fertilizer contains. Of these substances nitrogen is much the most expensive. It usually costs about three times as much per pound as either of the other two. In different localities, and in different years, the nitrogen in fertilizers usually costs from 14 cents to 18 cents per pound, while the potash and soluble phosphoric acid cost from 3 to 6 cents per pound each. If a fertilizer contains 4 per cent of nitrogen, 8 per cent of phosphoric acid, and 5 per cent of potash, each ton will contain 80 pounds of nitrogen, 160

pounds of phosphoric acid, and 100 pounds of potash. If we assume a value of 15 cents per pound for the nitrogen, and 5 cents for each of the other ingredients, we will have a value as follows:—

80 pounds of nitrogen at 15 cents	= \$12
160 pounds of soluble phosphoric acid at 5 cents	= 8
100 pounds of potash at 5 cents	= 5
Total value per ton	= \$25

It will readily be seen that such a fertilizer would really be cheaper at \$25 than one with 8 per cent of nitrogen, 6 per cent of phosphoric acid, and 4 per cent of potash would be at \$20, for the real value of the latter would only figure out \$19. It is usually a mistake to buy cheap, low-grade fertilizers, for even if bought at their real value, there is a larger proportion of inert matter or "filler" on which to pay freight and to handle in the field.

The valuable ingredients of fertilizers are obtained from many different sources. The nitrogen may be of either animal, vegetable, or mineral origin. Nitrate of soda, or, as it is sometimes called, *Chile saltpeter*, is found in large deposits in some of the drier parts of South America. It is used as a fertilizer in great quantities, either alone or combined with other substances. Being very soluble, and in a form to be immediately taken up and utilized by the plant, it acts very quickly, giving almost immediate results, the leaves taking on a darker color, and the plant showing increased vigor of growth within a very few days after its application. On account of its solubility, however, it is easily washed and leached away by the rain, and as it is expensive

it should only be applied in small doses, and just at the time when it will be most useful in the growth of the plant. It is much used by market gardeners, and sometimes as a top dressing for lawns and small grains. Sulphate of ammonia is another mineral source of nitrogen for fertilizers. It is a by-product of certain manufacturers. It, too, is very soluble, but it acts more slowly than nitrate of soda, since, before becoming available, it must be acted on by the soil bacteria, and be converted into the form of a nitrate. It is a valuable source of nitrogen, especially for heavy clay soils. If used in large quantities on sandy lands that are deficient in lime, an acid condition may ultimately be induced that will be harmful. Dried blood, tankage, and other slaughterhouse refuse, and fish scrap, the waste material from the manufacture of fish oil, are the usual animal sources of nitrogen. They are all extensively used, and give excellent results with most crops. All have to undergo fermentation and nitrification in the soil before becoming available. Dried blood undergoes the changes very quickly, but the tankage acts more slowly. This is sometimes an advantage for crops that need to be nourished during a long growing season. Guano, the dried excrement of sea birds found in certain desert islands off the Pacific coast of South America, should also be mentioned in this connection. It has been much used as a fertilizer and contains considerable nitrogen. The bat guano, found so abundantly in caves in many regions, has usually been subject to leaching by water, and so has lost most of its nitro-

gen. Occasional deposits are found, however, that are rich in this element. Stable manures, night soils, and other animal excrements, owe their value as fertilizers largely to the nitrogen which they contain. Vegetable substances, useful as fertilizers on account of the nitrogen they contain, are the residues left from the extraction of various vegetable oils. Castor-bean pumice and cotton-seed meal are the two most widely used for this purpose. For many years cotton seed and cotton-seed meal were the cheapest sources of nitrogen in the South, but now they are so extensively used for feeding cattle that the price rules higher. The immense importance as a fertilizer of the vegetable nitrogen contained in leguminous plants has already been sufficiently emphasized.

Phosphoric acid as found in fertilizers is always combined with lime. It is mostly derived from bones and from certain phosphatic rocks that are mined very extensively in South Carolina and Florida. It occurs in three conditions, known commercially as water soluble, citrate soluble, and insoluble phosphate. The first two are both supposed to be immediately available as plant food, and both are rated at about the same value. The extent to which the so-called insoluble phosphate becomes dissolved in the soil and thus becomes available depends on the fineness to which it is ground and the amount of vegetable matter in the soil. The chemical changes taking place in connection with the fermentation of vegetable matter aid considerably in its solution. The insoluble phosphate from

bones, too, becomes available more easily than that from rock phosphates. Sometimes the bone meal is treated with sulphuric acid to make it all soluble. It is then called dissolved bone. The rock phosphates are nearly always treated with sulphuric acid before being used. They are then known as acid phosphates or superphosphates. Bird and bat guanos all contain considerable quantities of phosphoric acid. The bat guanos in particular usually owe most of their value to this substance. Thomas slag, a by-product of certain iron furnaces, is considerably used in England and Europe as a source of phosphoric acid. Hard-wood ashes also contain a considerable percentage.

Potash for fertilizing purposes also comes from hard-wood ashes, but it is usually derived from certain potash salts that are extensively mined in Germany. Kainit, one of these salts in its crude state, is very largely used in the manufacture of low-grade fertilizers. It contains considerable quantities of common salt and other impurities and so is objectionable for tobacco and some other crops. The muriate of potash prepared from these crude salts is usually the cheapest form in which to apply potash, especially at interior points where high freight rates increase the comparative cost of the crude salts. It is useful for corn, cotton, potatoes, and all ordinary crops; but it cannot be used for tobacco, since chlorine in any form ruins the burning quality of the leaf, and it is claimed by some investigators that it should not be used for sugar cane as it is thought to increase the per cent of glucose and other impurities.

There is also some prejudice against using it with fruits and vegetables. In the highest grades of fertilizers, therefore, the sulphate of potash is usually employed although it is slightly more expensive than the muriate. Some growers of cigar tobacco go even farther and only use the still more expensive carbonate.

Commercial fertilizers are usually rather caustic, and if improperly used they may do much harm. Many kinds of seed will fail to germinate or the young plantlets will be killed if planted in direct contact with commercial fertilizers. Usually the best way to apply them is to open a furrow where the row is going to be, and scatter them in and cover from one to two weeks in advance of planting the seed. If more than four hundred or five hundred pounds per acre are used, the fertilizer should be mixed with the soil before covering by running a small shovel plow in the bottom of the furrow. If more than eight hundred or a thousand pounds per acre is used, only a part should be put in the furrow and the balance should be broadcasted and harrowed in. Where large quantities of very soluble fertilizers are used or where a crop has a very long growing season, it may be best to divide the amount and make two or three applications at considerable intervals. In most cases, however, this extra expense would not be justified and all should be applied in advance of planting. Some seeds like corn are quite resistant, and small quantities of fertilizer may be sown in the drill with the seed with safety. There are many seed drills in the

market with fertilizer attachments that can be used to plant and fertilize at the same operation. This is a considerable saving of labor. Various machines for drilling in fertilizers alone are also on the market. Where it is scattered by hand, a tin horn-shaped tube to deliver it in the bottom of the furrow is a great convenience, as it saves stooping and prevents it from being blown about by the wind and wasted. In fertilizing orchard trees it may be broadcasted about the tree and hoed or harrowed in, always taking care to scatter it evenly as far or a little farther than the branches extend; or if the trees are small, a furrow may be opened on each side of the row in which to scatter the fertilizer, which can then be covered with the plow.

It is always a matter of great practical importance to determine what kind and what amount of fertilizer to apply on any given soil and crop. Theoretically a chemical analysis of the soil should show in what elements it was deficient, and thus enable one to judge in what proportions to blend the different plant foods and what quantities of them to apply. Practically, however, this is seldom a safe guide. A chemical analysis may give some useful hints as to the probable needs of the soil, but the mechanical condition and the available water supply have such a powerful effect on plant growth that nothing short of practical trials continued for a term of years can give any real knowledge as to the needs of a given soil. Every intelligent farmer must, to a considerable extent, be an experimenter. Experience thus gained in one locality can, however, be utilized in others.

where the soil and climatic conditions are similar. Soil surveys, by means of which the different soil areas can be carefully mapped, are thus of great use in determining the proper use of fertilizers. The farmer can tell much, too, by closely observing his crops, as to their need for the different food elements. If the growth is slow and the leaves are small and yellow, it is an indication of the lack of nitrogen unless this condition has been caused by excessive drought. This element if present abundantly tends to induce a rank growth and gives a dark green color to the leaves. If, on the other hand, the leaves are dark and the growth rank while but little fruit or grain is produced, the lack of phosphoric acid is indicated. The phosphates promote fruitfulness and early maturity. Potash, on the other hand, tends to promote vigor and prolong the growing period. It is also supposed to give firmness and higher flavor to fruits, and in many cases it has a marked influence in promoting the health of plants and warding off disease. In a soil that is rich in nitrogen and phosphoric acid but deficient in potash the crop will start well early in the season, but it will be likely to show weakness later. The foliage is liable to become spotted and diseased, and the grain or fruit will be poor and light. Cases sometimes occur where soils are only deficient in some one or two of these elements, but in the great majority of cases all three will be found lacking, and a complete fertilizer will be required.

Rotation of Crops. — The whole subject of soil improvement, especially improvement by the use of green manures, is intimately connected with a

proper rotation of crops. It is, with few exceptions, extremely unwise to devote any given piece of land continuously to the same crop. Each crop draws on the food elements in the soil in different proportions, and where only one crop is planted the tendency is to exhaust the soil unequally. If this were the only difficulty, it would be easily overcome by the proper selection of fertilizers, but there are many others. Some crops, like cotton, require absolutely clean cultivation throughout the season. This, as has been previously pointed out, tends to the rapid exhaustion of vegetable matter. Other broadcast crops like the small grains cannot be cultivated at all, and if planted continuously the land becomes very foul with noxious weeds. Some crops occupy the land so continuously that they do not give time for the growing of leguminous catch crops for green manuring. The most imperative reason for crop rotation is, however, its usefulness in checking the ravages of diseases and insects. When the land is planted continuously to any given crop for a term of years, it makes ideally favorable conditions for the rapid multiplication of the diseases and insects peculiar to that crop. There are many instances in which, owing to continuous cropping, the land has become so infested with disease that the cultivation of the crop has had to be entirely abandoned. The bacterial blight of tomatoes and potatoes and the *Fusarium* wilt of watermelons and cotton may be mentioned as instances of Southern diseases that often become very destructive when these crops are grown continuously. Some investigators have re-

cently claimed to have proof that the exudations given off in the soil by the roots of certain plants are injurious to succeeding crops of the same kind. This would be an added reason for crop rotation. The regions where continuous planting is mostly practiced are those that are dependent on a single crop. One-crop farming is always dangerous, not only from its bad effect on the land, but for economic and business reasons as well. If a farmer grows but one crop, he is liable to lose his whole year's work through some unfavorable turn of the season, and if he succeeds in making a good crop, his returns from it will depend entirely on the course of the market for this one staple. Diversified farming is much safer. A season that is bad for one crop may be favorable for another, and it is seldom that the prices for all farm crops are unprofitable in any one year.

Just what crop rotation to adopt and how closely to follow it are questions that will have to be answered differently for different localities and almost for every farm. It must differ, not only with the locality, but with the kind of business in which the farmer is engaged. The stock raiser must adopt one rotation, the grain grower another, the cotton farmer another, and the truckman still another, if indeed the rotation does not lead a man to become a stock raiser as well as a grain or cotton grower. The general adoption in the cotton belt of a rotation that would necessitate the keeping of more live stock would be of untold economic benefit besides its great effect in preserving soil fertility. The following has been suggested as a suitable rotation for upland cot-

ton fields: first year, cotton; second year, corn with cowpeas planted between the rows, the field to serve as pasture after the corn is gathered; third year, winter oats or rye, to serve as winter pasture and to be cut for forage in the spring and be followed by cowpeas either for hay or to be pastured; fourth year, cotton. The general adoption of this or some similar rotation would so enrich the land and increase the yield of cotton per acre that the average farm would yield fully as much cotton per year as at present and the immense sums paid annually by the cotton states for beef, butter, bacon, hams, and lard would be saved. Whatever rotation is adopted, the main points to keep in mind are to see to it that leguminous crops of some kind be included as often as possible, that crops requiring clean cultivation be interspersed with those that cover and shade the soil, and that so far as possible deep-rooted plants alternate with shallow-rooted ones, and above all that plants liable to the attack of the same insects and diseases do not follow each other on the same land. With crops that occupy the land continuously for a term of years, like orchards or, in the tropics, sugar cane, rotation in the sense in which it is used with annual crops cannot be practiced. In these cases much of the advantage of rotation can be secured by alternating clean cultivation with the growth of leguminous cover crops. In the case of sugar cane the land, too, should always be planted to velvet beans or some similar rank-growing legume for a year or two, whenever it is necessary to plow up old fields before they are again replanted to cane.

THE GROWTH OF THE PLANT

The above discussion of soil improvement must be considered in connection with a brief consideration of how plants grow. The study of the life processes of plants is the subject-matter of that most interesting and important science, vegetable physiology. A knowledge of its principles is of fundamental importance for the farmer, since agriculture is after all only the practical application of vegetable physiology and soil physics. At this place only the barest outlines of the facts connected with the growth of plants can be attempted.

Within each seed is wrapped up a tiny rudimentary plantlet called the embryo. This consists of one or more seed leaves, the cotyledons, a minute bud or growing point called the plumule, and the radicle or rudimentary rootlet. There is also a greater or less amount of rich food material that has been stored either in the thickened seed leaves or in an enveloping layer called the endosperm. It is this stored food material that gives many seeds such great value as food for men and animals. Under favorable conditions of heat and moisture the young plantlet begins to grow. The seeds swell, the seed coats are ruptured, and the young plant emerges. This process is called germination. While it is in progress, the stored food material becomes soluble and is used to nourish the young plantlet as it pushes its first leaves up into the light and the advancing root tip is burrowing even more rapidly into the soil. If this rootlet is carefully examined, it will be seen that for a considerable space just behind the

extreme root tip it is covered with what looks like a delicate down or a weft of mold. On magnification this down is seen to consist of immense numbers of short delicate root hairs. These are the organs for absorbing water, together with the small amounts of mineral salts that the soil water always holds in solution. They are pressed close to the soil particles and so are in immediate contact with the films of water that, as we have previously seen, cling to each of these particles. After a few days or weeks the oldest of these root hairs die, but others are constantly forming near the younger root tips during all the period when the plant is in active growth. Although each single root hair is so small as to be invisible to the naked eye, their aggregate number is so great that their combined surface usually considerably exceeds the entire leaf surface of the plant. The growing of root hairs for absorbing the films of moisture that cling to the soil particles is thus seen to be the chief function of the roots of agricultural plants. Incidentally they also serve as holdfasts for anchoring the plant firmly in the soil and preventing its being blown away by the wind. In some special cases, as with the turnip and sweet potato, roots also serve as storage organs for holding reserve food supplies. This is always the case with these crops in which the root is the part having commercial value. All that has been written, therefore, about the soil and methods for its preparation for crops and its improvement is simply to insure that it be in proper condition for the roots to ramify freely and develop root hairs abundantly; and that the films of soil

moisture be present in sufficient quantity and that they contain enough of dissolved nutrient salts to provide an abundant supply of mineral food elements for the growing plants.

The principal function of the stem is to act as a framework on which to hang the leaves and display them properly to the action of air and sunlight. It also serves as a reservoir of moisture and its vessels and tissues provide for the transmission of the water and mineral salts absorbed by the roots to the leaves in which it is elaborated into plant food. It also serves for the distribution of the prepared food from the leaves to nourish all parts of the plant. In some cases, too, stems like roots become swollen and serve as special reserve food storehouses.

The leaves are the laboratories where the crude mineral food elements are combined with the carbonic acid of the air and so elaborated that they can be utilized for the nutrition and growth of the plant cells. It is this power to utilize mineral elements as food that chiefly serves to distinguish plants from animals. All green-leaved plants can do this, but animals must depend for food on materials that have already been elaborated by plants. In almost all other respects their life processes are identical. Every living cell, whether of plant or animal, must have proteids and carbohydrates for food and must breathe or absorb oxygen and give off carbonic acid as the result of those chemical changes from which its vital energy is derived. The plant can make its proteids and carbohydrates, the animal cannot. Carbonic-acid gas always exists in the atmosphere.

It is supplied as the result of combustion, of fermentation and putrefaction, and from the respiration of plants and animals. The process by which it is taken up and used as food by green plants is known as photosynthesis. This is accomplished by the agency of chlorophyll, the green coloring matter of the leaves, when this is acted on by strong light. During this process carbonic acid is absorbed and a considerable quantity of oxygen is liberated, thus masking and reversing the ordinary process of respiration. At night or when in artificial darkness respiration continues and photosynthesis ceases, so that then green leaves behave like other living tissues and absorb oxygen and give off carbonic acid. Since light then plays so important a part in the nutrition of plants, we can readily see that the leaves are special organs for exposing green chlorophyll-bearing tissue to the action of light. This fact has an important practical bearing on methods of cultivation. Plants that are crowded too closely together can never grow as large or develop as rapidly as those that have sufficient space in which to unfold their leaves. Different kinds of plants vary widely in the amount of light which they require in order to attain their best development. Some are adapted to the dim half light of deep forests and cannot endure the full strong sunlight. Others are adapted to the open, and thrive best where the light and heat are strongest. The agriculturist in the tropics in particular must know the requirements of his different plants as to light, and must regulate his practices accordingly.

Another important function of the leaves is that of throwing off surplus moisture by transpiration. As this moisture which was derived from the soil through the agency of the root hairs is given off in the form of vapor, all of its dissolved mineral salts are left behind in the leaves, where they are combined with the carbohydrates produced by photosynthesis to form the complex food substances required for the nourishment of the plant cells. The throwing off of water during transpiration causes the leaves to also act as pumping engines and induces the constant upward movement of the crude sap. In moving trees or plants when in leaf this pumping action of the leaves must not be forgotten and the leaf surface must be greatly reduced by pruning. Otherwise the plant will wither and die from want of water before new root hairs can be formed with which to absorb it. Deciduous trees should always be moved when out of leaf. Even then the top should be heavily pruned to avoid too great a display of leaf surface in the early spring before the new root system has had time to develop.

In some special cases, as with the cabbage, leaves may become so altered as to serve as receptacles for storage of reserve food materials.

Roots, stem, and leaves are all organs that are concerned in the growth of the individual plant, but the chief office of the flowers is the reproduction of new individuals in order to secure the perpetuation of the species. Flowers present many variations in form, structure, size, and color. In most cases, however, there are four sets of organs. The outer, called

collectively the calyx, are for protection. They are usually green in color like the leaves; they serve to wrap up and protect the other organs while they are young. The next set, called the corolla, are for display. They also serve to protect the more important organs within, but their chief function seems to be to attract insects. The central essential organs which are so carefully wrapped up by the calyx and corolla also are of two kinds, the stamens and pistils. The stamens produce a considerable quantity of a yellowish powder called the pollen. This represents the male element. At the top of the pistil is a moist sticky surface called the stigma. When a pollen grain falls on this, it adheres to it and begins to grow, sending out a slender microscopic tube which penetrates the tissues of the pistil, finally reaching the enlarged base called the ovary, where the egg cell or female cell is located. The nucleus of the pollen grain passes down through the tube, enters the egg cell, and unites with its nucleus, — thus effecting fecundation. The fecundated egg cell now begins to divide and grows into the rudimentary plantlet called the embryo. This with its surrounding supply of reserve food material and its various protective coatings constitutes the seed which, when planted under favorable conditions, will germinate and grow into a new plant like the one from which it sprung.

It seems to be almost a universal rule in nature that the young will be more vigorous when the male and female cells from which they spring are not too closely related. We therefore find some kinds of

plants where the pistils are borne on one individual and the stamens on another. In order to produce seed it is necessary for the pollen to be conveyed in some manner from one plant to the other. There are other cases where the stamens are in separate flowers, but borne on different parts of the same plant. Even, as is usually the case when both occur in the same flower, there are many contrivances to prevent the pistils from being pollinated from the same flower. All of these cases require what is known as cross pollination; that is, the carrying of pollen by some means from one flower to another. There are some plants, however, where the flowers are normally self-pollinated. Even in these cases cross pollination undoubtedly often accidentally occurs. Some plants produce pollen in immense quantity and depend on the wind for carrying it from one plant to the other. This is a wasteful method and unduly taxes the energy of the plant in the production of useless pollen. The great majority of plants depend on insects of one kind or another to carry pollen from flower to flower. The manifold devices that have been evolved for securing insect pollination constitute one of the most marvelous wonders of the vegetable world, and this interrelation between plants and insects furnishes a most interesting and important field for study.

INSECTS AND DISEASES

Cultivated plants of all kinds are liable to be attacked by insects, and they are, like animals, subject to various diseases. The study of the diseases of

plants is the province of vegetable pathology. This is one of the youngest of the great group of biological sciences, since most of our knowledge of plant diseases and their remedies has been gained during the last twenty-five years. It has, however, the greatest possible practical importance for the farmer, for by the practice of its teachings he can often save his crops from enormous losses. Economic entomology is sometimes considered as being distinct from vegetable pathology, but it is really only a branch of that important subject. In a general work of this kind it is impossible to give more than the barest outlines of pathology, and the reader is referred to special works on this subject for a more comprehensive treatment.

Plant diseases may be divided into three general groups: environmental diseases, functional diseases, and diseases caused by parasites. In the first group are placed all those morbid conditions caused by uncongenial soils, lack or excess of water, or bad climatic or atmospheric conditions. Here, too, would be classed accidental mechanical injuries of all kinds. The only possible remedies for diseases of this class consist in improving the environment or preventing the injuries. If the soil is too wet, it can be drained; if too dry, it can be irrigated; if too poor, it can be fertilized. Atmospheric and climatic difficulties are more difficult to avoid, but even here something can be done by planting shelter belts, or giving artificial protection by fires, tents, sheds, etc. The wise farmer will, however, study his surroundings and only plant the kinds of crops to which they are best adapted.

The term "functional disease" is applied to a class

of obscure disorders in which the life processes of the plant are disturbed, and the organs fail to perform their proper functions without any apparent external causes for the abnormal conditions. These diseases are as yet poorly understood, and they have not been sufficiently studied; but so far as is known they are connected with the improper, either excessive or insufficient, secretion of enzymes. These are powerful chemical ferments that are secreted by many cells. It is by their aid that the reserve food stored in so many different parts of plants is made soluble and available for growth and that many of the other life processes are carried forward. The digestive fluids of animals also contain enzymes. When these powerful compounds are produced for any reason at the wrong time or in the wrong quantity, serious complications follow. Peach yellows and the mosaic disease of tobacco may be mentioned as well-known examples of functional diseases. So far, unfortunately, no remedies are known for this class of troubles, and they must still be classed as incurable.

Insect injuries of all kinds are here grouped under the head of diseases caused by parasites, for while some of the losses caused by insects are not, strictly speaking, diseases at all but only mechanical injuries, these grade so imperceptibly into those that cause derangement of function or abnormal growth of tissue that it is impossible to draw a line between them. Parasitic diseases may be classified according to the nature of the damage caused, according to the part of the plant attacked, or, as is more often done, according to the nature of the parasite. Plant parasites

may be either animals or other plants. Plants that are parasitic on and cause diseases of our cultivated plants are to be found among the bacteria, the slime molds, the fungi, and in a few cases even among other flowering plants. In warm moist countries damage is also sometimes caused by epiphytes. These are air plants that do not enter the tissues of the plants on which they grew, but they cause trouble by crowding and keeping out light and air. Epiphytes are found among the algae, the lichens, the mosses and liverworts, and among flowering plants. Animals causing injury to plants are principally found among the nematode worms, the mites, and the insects. Slugs and snails which belong to the molusca are also troublesome, but their injuries, like those caused by the grazing of the higher herbivorous animals, are to be classed as mechanical injuries rather than as diseases.

Remedial measures against plant diseases may be grouped under hygienic measures, including the destruction of sources of contagion and rotation of crops; soil treatment; seed treatment; topical applications to the plant itself; and the propagation and selection of immune varieties.

Bacterial diseases are exceedingly common and difficult to combat. Pear blight, the bacterial blight of potatoes, tomatoes, etc., the black rot of cabbage, and the bud rot of the cocoanut may be mentioned as typical examples. Hygienic measures, especially the destruction of diseased plants or parts of plants, and rotation for the annual crops, are as a rule the only remedies, and these are far from satisfactory.

Sprays or other topical applications are useless. The most promising work for the future lies in the selection of resistant or partially immune varieties and strains.

Slime molds cause but few diseases. The ones best known are the club foot of cabbages and turnips and the crown gall of peaches and other fruit trees. Heavy applications of lime to the soil have been shown to be an almost complete preventive for the first of these diseases, but no remedy is known for the crown gall.

By far the larger number of vegetable plant parasites are to be found among the fungi. They cause all such well-known diseases as smuts, rusts, cankers, leaf spots, anthracnoses, scabs, mildews, molds, and root rots. The nature of the treatment depends largely on the part of the plant attacked. The superficial powdery mildews can be killed with sulphur. Most parasitic fungi, however, penetrate within the tissues of the host plant. Those that reach the plant from above ground can usually be prevented by keeping the plant coated with fungicidal sprays like Bordeaux mixture and thus preventing infection. Once within the plant tissue the parasite is safe and cannot be reached by applications. Sprays are thus preventive, not curative, an important distinction that should never be lost sight of. If the contagion reaches the plant from the ground through the roots, it cannot be prevented by spraying. In these cases soil treatment is sometimes available, but reliance must mainly be had on rotation of crops. Many smuts may be prevented by treating the seed. Relief from fungous

diseases is sometimes possible through the finding of immune varieties or through better cultural methods.

The dodders and broom rapes are among the best-known parasitic flowering plants. They are usually pests of minor importance and like other weeds should be eradicated by preventing the forming of seed.

Nematode worms are minute microscopic animals, some of which are parasitic on plants. The worst damage is done by one that causes gall-like swellings on the roots of many of our cultivated plants. They are very troublesome on many sandy soils in the Southern states and other warm countries, and they are also a serious pest in greenhouses. Here they may be destroyed by thoroughly sterilizing the soil with live steam before placing it in pots or trenches. In the fields nematodes can only be combated by careful crop rotation.

The mites are minute animals related to the spiders. Only a comparatively few kinds of them are troublesome, but they include such well-known pests as the various red spiders and the rust mite of the orange. Applications of sulphur are usually the most effective remedy for mites. It may be applied as a powder by means of the so-called powder gun, or it may be suspended in water with a little flour paste to make it stick and be applied as a spray.

By far the greatest number of animal plant pests belong to the insects. An immense variety of species prey on our cultivated plants in countless numbers and do damage of a great many different kinds. For practical purposes, however, they may all be considered

under three groups : burrowing insects, biting insects, and sucking insects. No general rule can be given for the treatment of burrowing insects. Each one must be carefully studied by itself to see at what stage of its life history it can be most successfully attacked. Often the eggs are laid on the surface of their food plant, and the young feed for a short time superficially before beginning to burrow. In such cases they may be killed by arsenical sprays like other biting insects. In other cases it is possible to prevent the depositing of eggs by various protective measures. The one almost universal remedy for biting insects is to poison them by spraying their food plants with some arsenical compound. Sucking insects have mouth parts arranged for piercing the epidermis of the food plant and sucking out the elaborated sap. They are much more difficult to reach than most biting insects since they cannot be killed by arsenical poisons. It is necessary to employ what are known as contact poisons ; that is, some substance that will kill the insects by simply coming in contact with it. The principal contact poisons are kerosene, whale-oil soap, resin mixture, tobacco extract, and pyrethrum powder. The first three are much the strongest and most effective, but they have to be used with great care or they will injure the plants. Tobacco extract is only used for very soft-bodied insects like plant lice. Pyrethrum powder is safe and will not injure the most delicate plant. When fresh it is quite effective, but it soon loses its strength, and the commercial article is often unsatisfactory. In greenhouses fumigation with tobacco smoke is more effective than spraying with

tobacco extract, and a standard remedy for scale insects on fruit trees is to cover them with a tent and fumigate with hydrocyanic-acid gas.

Spraying for insects and fungi has now become so important a part of the best farm practice in the production of many crops that the subject demands a little fuller consideration even in a work of this kind. Spray pumps for applying insecticides and fungicides are now on the market in almost every conceivable form and size, from the little hand atomizer with a reservoir holding a quart or less to powerful machines with pumps run by gasoline engines and tanks holding hundreds of gallons. Spraying is now a recognized necessity in the production of nearly all tree fruits and of many vegetables. It is almost universally used for potatoes, but is too expensive to be employed for most other ordinary farm crops. Tobacco and cotton growers usually apply insecticides in the form of a powder. The substances mostly used for spraying are, first, the arsenic compounds, Paris green, London purple, white arsenic, and arsenate of lead. These are the recognized remedies for biting insects. Second, the contact poisons used for sucking insects: kerosene, either as the mechanical mixture with water or the emulsion, whale-oil soap solution, resin-lime mixture, and tobacco extract. Third, various copper compounds used as fungicides. The most important by far is Bordeaux mixture. Paris green is often added to Bordeaux mixture, thus affording protection from the biting insects and fungi by the one spraying. Fourth, sulphur in suspension or potas-



Knapsack Spray Pump.



Barrel Spray Pump.



Automatic Spray Pump.

sium sulphide in solution as a remedy against mites and powdery mildews. Formulas for these different sprays are as follows: —

Paris Green. — Use 4 ounces to 50 gallons of water or of Bordeaux mixture. Keep constantly agitated. Two pounds of flour boiled to a paste may be added to the water when used alone. Limewater used with Paris green prevents burning of foliage. To apply as powder, mix with 20 to 30 parts of flour, slacked lime, or finely sifted wood ashes.

London Purple. — Use the same as Paris green. Its composition is variable and its use not always satisfactory.

Arsenite of Lime. — Boil 1 pound of white arsenic in 4 quarts of water. Use this to slack 2 pounds good quick-lime. Add water to make 2 gallons as stock mixture. For use add 1 quart to each barrel of water or Bordeaux mixture.

Arsenate of Lead. — Add 1 to 2 pounds to 50 gallons of water or Bordeaux. It burns foliage less than Paris green.

Kerosene Emulsion. — Boil $\frac{1}{2}$ pound laundry soap in 1 gallon soft water. While hot, add 2 gallons kerosene and churn violently 5 to 10 minutes. Dilute with 4 to 20 parts of water before using. (Strong emulsions are for scale insects in winter.)

Kerosene in Mechanical Mixture. — Use special pump. Set to throw 5 per cent to 25 per cent of kerosene.

Crude Petroleum. — Use same as kerosene.

Whale-oil Soap. — Use 12 to 15 pounds of the potash soap for each 50 gallons of water.

Resin Mixture. — Boil 20 pounds resin, 5 pounds caustic soda, and 3 pints fish oil with 20 gallons of water for at least 3 hours. Add hot water to make 50 gallons. Use in winter. For use on foliage dilute to 150 gallons.

Sulphur-lime Mixture. — Mix 18 pounds flowers of sulphur with 50 gallons boiling water. Slowly add 21 pounds quicklime. Boil 30 to 50 minutes.

Tobacco Extract. — Cover a quantity of tobacco stems with boiling water and allow to stand 5 hours. Dilute with 4 parts of water. Or use 1 pint commercial "Rose Leaf" tobacco extract to from 10 to 20 parts of water.

Sulphur. — Use as a powder; or add 3 to 5 pounds to 50 gallons of water containing 2 pounds of flour boiled to a paste and apply as a spray. Agitate thoroughly.

Potassium Sulphide. — Two to three pounds potassium sulphide, water 50 gallons. Use at once.

Bordeaux Mixture. — Dissolve 6 pounds of copper sulphate in 25 gallons of water. (This is best done by suspending it in a coarse sack near the top of the water.) In another barrel slack 6 pounds of quicklime and dilute to 25 gallons. Pour the lime wash slowly into the copper-sulphate solution and stir well. Use at once. For peaches use only 2 pounds copper sulphate.

Ammoniacal Copper Carbonate. — Dissolve 5 ounces copper carbonate in 3 pints of strong ammonia (26° Beaumé) that has been diluted with 8 parts of water. Add water, 50 gallons. Use in place of Bordeaux when staining by the latter is objectionable.

In all spraying operations success will depend on the thoroughness with which the work is done, and on the judgment with which the work is timed. As most sprays are preventive rather than curative it is usually necessary to begin the work before any sign of the trouble appears.

MARKETING PRODUCTS

It is not only necessary to grow good crops, but they must be sold. The successful farmer must be a

good business man as well as a good agriculturist. Farm crops are produced for use at home or on the farm ; for sale in the market of the home town that can be reached direct by the farmer's wagon ; for shipment to some distant market requiring the use of railroad or water transportation ; or for export to some foreign market.

It should be the first duty of every farmer to see that his home table is always abundantly supplied with all the food products that can be produced in his neighborhood. No one is so favorably situated for living well as the farmer. With only slight additional effort and expense he can always have the best and freshest of fruits and vegetables, eggs, milk, and butter. Those who live in towns know how expensive it is to keep their tables supplied with these products and how difficult or often impossible it is to get them in really fresh appetizing condition. Yet how many farmers there are who fail to avail themselves of this, which is one of their greatest privileges, but spend their hard-earned money for buying from the groceries inferior foods that have been shipped in from some neighboring city market. Such a condition is almost unbelievable, but it is so common as to be the rule rather than the exception. It will be a great day for the average health and prosperity of the country when every farmer realizes that the crops consumed on his home table are the most profitable ones he can grow and when each takes a pride in seeing how near he can come to "living at home." Other crops that are consumed on the farm are, of course, mostly the grain and forage fed to animals.

This is marketed later in the form of eggs, milk, or meat. Animal husbandry is a very important branch of agriculture, but its bearings will be discussed under another heading.

Crops grown for the home market are usually sold direct to the consumer, or at most only pass through the hands of the local grocer as a middleman. This is a very simple and on many accounts a very desirable business arrangement. The farmer can consult the needs and tastes of his customers and by supplying their wants he can be reasonably sure of fair prices for his products regardless of the fluctuation in the great market centers. By careful attention to growing his crops well and preparing them for market attractively he can soon make a local reputation for his goods that will always secure a ready sale, and he has the great advantage of being able to grow and sell a diversity of crops. The man who grows only one or two market crops runs greater risks of loss from an unfavorable season or from the fluctuations of the market than the one who has a number of different crops. Weather conditions that injure one may benefit others, and it is seldom indeed that prices for all farm products are disastrously low at the same time. With perishable products the grower for the home market has the further advantage of being able to sell them when fresh and in the best condition, and he is not liable to the heavy losses due to deterioration in transit so often met by those who ship such crops to a distance. It is indeed remarkable how often the advantages of a home market are overlooked and in how many cases small towns and rural communities

are poorly supplied with the very things that might be produced in the neighborhood in the greatest abundance.

With crops grown for distant shipment a distinction must be made between what are called staple farm products and those, like fruits and vegetables, that are of a perishable nature. The former crops, like wheat, corn, cotton, etc., are usually sold at the nearest shipping point either to local speculators or to representatives of the great commercial interests at prices fixed from day to day by their value in the great world's markets and by the transportation charges necessary to reach these markets. The price received depends but little on the efforts of the farmer and is only too often manipulated by the commercial interests so that it shall be abnormally low at the season that the crop is being marketed followed by a marked rise as soon as the bulk of the crop has passed out of the hands of the producers and before it passes to the consumers. This constantly tempts the grain and cotton farmer to turn speculator and to hold his crop for a rise in value.

Perishable crops, too, are often sold direct by the farmer to produce merchants or local speculators. Sales of such products at the point of production are probably slowly increasing, but the risks attending the handling and storing of such products are so great that a very large part of the fruit and vegetables produced are shipped at the farmer's risk, and are sold for his account on commission. This system leaves the farmer entirely at the mercy of unscrupulous commission men and, unfortunately, there are

some of this kind, as well as many honest ones, and it has many other manifest disadvantages. The very fact, however, that so large a proportion of the immense volume of produce business is still done on this basis shows that there must be other weighty points in its favor. There can be no question but that, as a general rule, it is much better and safer for the farmer to accept a fair, reasonable price for his produce at home rather than to take the risk of shipping it on commission ; yet this very element of risk seems to be an attraction, and it is often much more difficult for produce merchants to buy their supplies in the country than to buy them from the commission men after shipment. The principal reason, however, why direct buying has not become more general, is the great difficulty of securing goods of a known and uniform quality. The staple products are all graded and sold by sample, so that the quality of any given lot is pretty accurately known. This is not possible with fruits and vegetables, where the quality and value of the same lot may vary so widely from day to day. The best remedy so far devised to meet this condition lies in the formation of shipping associations and the establishment of coöperative packing houses, where all the produce of a neighborhood can be brought in, and be assorted and packed uniformly. Each packing house of this kind handles enough produce so that its goods become known on the market, and this is a great advantage either in making direct sales or in selling on commission.

To successfully carry on a large business in the growing and shipping of perishable fruits and vege-

tables requires a rare combination of abilities. Besides exceptional skill as an agriculturist in the production of the crops and the usual commercial ability required in the transaction of any large business, one requires to have a wide knowledge of market conditions and requirements in different parts of the country, and to be a close student of transportation problems. He must also have the ability to impress his views on the transportation companies. None of the modern improvements in transporting perishable goods have come on the initiative of the transportation companies. Fast fruit trains, ventilated cars, and finally the vast system of refrigerator transportation, all have come on the insistent demand of clear-sighted farmers who realized how much the growth and extension of their business depended on obtaining improved transportation facilities.

The shipping of agricultural products to foreign countries is mostly in the hands of the large commercial interests, and is but little done by the farmers themselves. It therefore need not be discussed here. No matter what market crops are intended for, the fact should never be lost sight of that success will depend quite as much on the care and skill with which the marketing is done as on the ability to produce large crops.

FARM POLICY AND MANAGEMENT

In this age of specialization it has come to pass that there are many kinds of farms and many methods of farming. One of the first and most im-

portant questions that confronts the agriculturist is to decide what kind of a farmer he wants to be and what kinds of farming will give best results under his special local conditions. In making his decision he must consult, not only his own preferences and abilities and his available capital, but the nature of his soil and climate and particularly the character and needs of his available markets and his transportation facilities. A certain amount of specialization is undoubtedly desirable. The man who undertakes to grow too many crops will succeed with none of them. There are many cases, too, where either on account of special skill and knowledge or peculiarly favorable local conditions a farmer's wisest course is to confine himself exclusively to some one or two specialties. In general, however, diversified farming is safer and more profitable and lends itself much more readily to a proper rotation of crops and the preservation of the fertility of the land. The all-wheat, all-corn, or all-cotton farmer is seldom permanently prosperous and he inevitably leaves an inheritance of depleted acres to his successors.

The average farmer should first and foremost see to it that he produces at home, so far as possible, everything that is to be consumed on the farm. Second, he should study the possibilities of his local market carefully and seek as far as possible to supply it. The man who produces the bulk of his own supplies and sells enough produce to his neighbors to furnish his other necessities is assured of success no matter what the state of the market for the great staples. It is true that it takes more care

and trouble on the part of the farmer and his family to do a retail business of this kind than to dispose of a grain or cotton crop to some larger dealer, but the result will usually amply repay the extra effort. Many farmers are, of course, so located that they cannot take advantage of local markets, but neglected opportunities of this kind are to be found on every hand. Extensive observation in many regions gives convincing proof that very few towns and cities have a really adequate home supply of those products that could be easily produced in the neighborhood. The abandoned farms in New England bear eloquent testimony to the shiftlessness and incompetence of their owners. It is true they could no longer produce hay and grain in competition with the richer level lands of the West, but the country has a dense manufacturing population and there is not one of these abandoned places that is not in easy reach of some prosperous town which is compelled to draw the bulk of its food supplies from the great markets of New York and Boston. The lands within a hundred miles of New York City are nearly all excellently adapted to small fruits, but it is a notorious fact that when the local season comes on berries are scarcer and higher in that market than when they are being brought from the Carolinas and from Delaware and Maryland. On account of their favorable soil and climatic conditions, which permit of the cultivation of many temperate as well as of all tropical products, the farmers of Cuba are in a position to produce a very unusually large variety of crops. As a matter of fact they devote themselves

so exclusively to sugar cane and tobacco that the towns are very poorly supplied with even the commonest fruits and vegetables, and immense quantities of such food products as corn, beans, rice, and potatoes are annually imported.

It is usually only those farmers who are located near the large centers of population that can find a local market for all of their produce, and it becomes necessary for them to devote at least a part of their energies to the production of some staple to be sold in the great markets. The nature of this staple must depend largely on transportation facilities. Those farmers who are distant from railroad or water transportation must depend on live stock which can carry itself to some shipping point, or on products like coffee or tobacco that are valuable enough in proportion to their weight to stand expensive transportation by wagon or pack train. In most of the more inaccessible regions the live-stock industry is the only available kind of agriculture. The importance of live stock is, however, not confined to such out-of-the-way places. On every farm there are unsalable products of various kinds that can best be utilized by feeding to live stock. Thus half the feeding value of a crop of corn is in the leaves and stalks. This is lost if only the ears are gathered and sold. The straw from small grain and the seed of cotton are useful stock foods, and so with many other products. Whenever possible, enough live stock should be kept on every farm to utilize all products that would otherwise be wasted. Another very obvious advantage from keeping live

stock is the production of a home supply of manure. When cattle or other domestic animals are properly handled, we get good value for the food consumed in the milk or meat produced, and we also get back at least three fourths of the fertilizer value of the food in the form of manure. Many farmers are content to buy and feed cattle when the advance price at which they can be sold no more than pays for the food consumed as they consider that the value of the manure secured constitutes a good profit. This feature of stock raising should be carefully considered in connection with what has been previously said in regard to the raising of leguminous crops for soil improvement as part of a crop rotation. The best possible use to make of a leguminous crop is to feed it to live stock. The legumes make rich feed since they contain so large a per cent of nitrogen, and when the crop is properly saved and fed the farmer gets a full return for its food value, and in the manure saved he has nearly its full fertilizer value as well. The average Southern farmer will make no mistake if, after setting aside sufficient land for gardens and orchards for supplying his own table and selling to his less provident neighbors, he shall divide his other fields in such a way as to secure in his rotation at least two crops of cowpeas or other legume every three years and shall keep enough hogs and cattle to consume the legumes and other waste products. The amount of corn, cotton, or other staple crop sold will, in a series of years, from the improved condition of his soil, be fully as great as if all his land had been devoted con-

tinuously to his one staple crop. He will have in addition the profits derived from his live stock and the greatly increased value of his lands.

The production of fruits and vegetables for distant shipment is a highly specialized line of agriculture and as a rule should only be embarked in by those having some special knowledge of or aptitude for the business. In this industry proper transportation facilities are the very first desideratum. Suitable soil and climatic conditions must also be carefully considered as well as an available supply of labor. For many reasons it is usually better for one who contemplates beginning in the fruit or vegetable business to go to some point where it is already successfully established. A beginner in a new region will encounter many difficulties that would be already solved for him at these recognized centers of the industry.

PART II

THE CHIEF SOUTHERN AGRICULTURAL CROPS

SUGAR CANE (*Saccharum officinarum* L.)

THIS giant among the grasses is supposed to be a native of southern Asia, but it is now one of the most important economic crops of tropical and sub-tropical countries in all parts of the world. Formerly it was practically the only source for the world's sugar supply since the amounts made from maple sap, from sorghum, and the sugar palm have always been so small as to be negligible. Of recent years, however, the sugar beet has been so improved by seed selection and better methods of cultivation that it has become a formidable competitor, and to-day it furnishes fully half the sugar that finds its way to the world's markets. The history of the beet-sugar industry is very instructive, since it illustrates so forcibly the immense improvement that may be made in agricultural methods as the result of persistent scientific study. A hundred years ago beets contained about five per cent of sugar. To-day the best strains of seed yield fifteen per cent to twenty per cent, and the tonnage obtained per acre has also been considerably increased. This is no chance result, but it has come from steady and persistent effort in plant breeding and in methods of

cultivation and the use of fertilizers. Improvements in manufacture have also kept pace with these improvements in production, and the business is now one of the best examples of a scientifically conducted agricultural industry. Sugar beets can be grown in many parts of the region that it is intended to cover by this volume, but since it is not yet a recognized Southern industry, no discussion of the question will be undertaken.

While these great improvements have been going on with beets, methods of cultivating sugar cane have in most countries practically stood still. The greater part of the world's supply is still produced by the methods in vogue a hundred years ago. Signs of progress are, however, not wanting. In certain countries, particularly Louisiana, Hawaii, and Australia, cultural methods have been revolutionized with the result of markedly increasing the yield and lessening the cost of production. These changes in method have largely been due to the initiative of the agricultural experiment stations which have been established in these countries. In Java, too, where much good scientific work has been done, there has been notable progress along many lines ; but owing to the high price of land and the abundance of cheap labor, cultivation there is still done by hand implements. In the other countries mentioned hand labor has been almost completely superseded except in the harvesting of the cane, with the usual result of greatly decreasing the cost of production.

Chief Uses. — Sugar cane is, of course, principally used for the production of sugar, with molasses, rum,

and alcohol as by-products. In some regions where cane is only produced on a small scale the juice is mostly converted into table syrup instead of being boiled down enough to make sugar. With the old method of open-kettle manufacture much of the molasses was also used for the table, but with the modern vacuum-pan methods the sugar is extracted so much more completely that the resulting molasses is used only for stock food or for distillation. Sugar cane is also used as a forage. It is well liked by cattle, horses, and hogs. Doubtless cane could profitably be used much more widely for feeding purposes than it is at present. The yield of forage per acre is larger than that afforded by any other crop.

Climatic Conditions. —Cane thrives in all parts of the tropics where there is sufficient rainfall or where it can be irrigated. It is not confined to strictly tropical countries, but can be grown with greater or less success as far north as central Alabama and Mississippi. Cane would grow vigorously much farther north than this, but the seasons are not long enough for it to mature properly and gain its full sweetness, and there would be much difficulty in keeping the seed canes over winter. In fact in practice the northern limit of its cultivation is largely determined by the possibility of wintering the seed cane. The distribution of the rainfall is a very important matter in successful cane growing. Abundant moisture is needed throughout the entire growing season in order to secure heavy yields, but dry weather in which to mature and harvest the

crop is equally essential. The best climate for cane is one where the rainy season lasts uninterruptedly for six or eight months and is then followed by a well-marked dry season for the remainder of the year. Continuous rainy weather gives no chance for the ripening and harvesting of the cane.

Soils.—Moist, heavy, rich soils are considered the best for cane, and its commerical cultivation is usually confined to lands of this character. Surface drainage is, however, essential, and low-lying lands with a retentive subsoil must be thoroughly ditched. As a matter of fact cane will grow splendidly on light sandy soils if moisture conditions are right, but such soils are very soon exhausted and require heavy applications of fertilizers. The poor, sandy pine woodlands of southern Mississippi, Alabama, and Georgia yield enormous crops by cane when "cow-penned" or otherwise heavily enriched. It is, however, only grown in these regions on a small scale for syrup making. In Louisiana and Texas commercial cane planting is mostly confined to the rich alluvial river lands. Here drainage is a prime necessity and much expensive ditching has to be done. Special methods of cultivation, too, have been devised to meet these soil conditions. In Hawaii the soils are mostly lighter in character and are largely of volcanic origin. Most of the larger estates are located in regions of insufficient rainfall, where it is necessary to employ irrigation. This, of course, profoundly affects methods of cultivation. In Cuba three distinct types of cane soils may be recognized. First, the red lands; these are heavy, tenacious soils,

but they have a jointed structure that allows the rains to pass down very readily. They have no subsoil, but extend downward unaltered to the bed rock, which consists of a cavernous coralline limestone with many underground channels through which the water is quickly carried away, thus affording perfect underdrainage. These soils are admirable during the rainy season, but suffer somewhat during the dry season. In Cuba these seasons are usually quite well marked, the summer being wet and the winter dry. Second are the heavy black soils overlying a white, calcareous, chalklike subsoil. These lands are usually undulating or even hilly, so that surface drainage is good and no ditching is required except in occasional low places. Third are the heavy, black, level soils underlaid by a retentive clay subsoil. These are very productive when properly handled, but would all be improved by additional ditching. The cane lands in the other West India islands and in Mexico and Central America are of various kinds, but so far as their cultural requirements are concerned they are comparable to some one or the other of the ones mentioned above.

Methods of Cultivation; Louisiana. — The methods of cultivation on the best Louisiana plantations may be briefly summarized as follows. It must be remembered that here the two chief aims are to get rid of surplus water and to secure the early maturity of the crop. A three-year rotation is usually practiced, two years in cane and one year in corn and cowpeas. After the second crop of cane is harvested the land

is plowed and is planted to corn very early in the spring. At the last cultivation of the corn, cowpeas are broadcasted at the rate of one to three bushels per acre. After the corn is gathered these produce an immense mass of vegetation which together with the corn stalks are plowed under with a disk plow during the latter part of summer. In about four weeks the vines will have rotted enough so that the land can be bedded. This is done with a large two-horse turning plow, and the beds or ridges are thrown up about six to seven feet apart. These beds are crossed by quarter drains at sufficiently frequent intervals, which lead into the larger ditches and these in turn into large drainage canals, so that any excessive rainfall is quickly carried away. Planting begins about the first of October or as soon as the seed cane is sufficiently mature to insure good germination. Planting furrows are opened in the top of the ridges with a double moldboard plow, but this furrow should not be quite as deep as the water furrow between the rows. Two rows of seed cane are laid in the bottom of this furrow, which is then filled in five or six inches deep by means of the disk cultivator. It is covered thus deeply to protect the seed cane from freezing during the winter. The cane is planted full length as it is found to keep better than when cut in short pieces. About four tons of seed cane are required per acre. Planting is usually interrupted at the beginning of the grinding season in November. On most plantations it is necessary to make spring plantings also. For this purpose seed cane must be carried over winter by the process

known as windrowing. The cane cut from two rows is carefully piled in the water furrow between them in such a way that the stalks of one armful are completely covered by the tops of the next. When the windrow is completed, only a continuous row of tops and leaves is visible. Furrows are now thrown from either side with large plows and the work of completely covering with dirt is finished with hoes.

In severe winters the windrowed cane is sometimes damaged so that a larger quantity of seed will be required to secure a stand. With the first warm days of spring the dirt is thrown from the sides of the beds with the plow and the greater part of the earth which covers the cane is scraped off with hoes. This lets in the warmth of the sun and promotes early germination. Fertilizer is now scattered in the side furrows and as soon as germination is completed the dirt is thrown back with a turning plow and the water furrows are cleaned out with the double moldboard plow. The subsequent cultivation is all done with disk cultivators, which throw still more dirt to the rows, and with the Magnolia or some other similar form of cultivator for the water furrows. No hoeing is needed after the first scraping of the dirt from the seed canes. In fact even this is sometimes done with a special implement devised for the purpose. When the cane tops begin to meet between the rows, it is "laid by," by again cleaning the water furrows with the double moldboard and opening up the quarter drains, which should be six inches deeper than the bottom of the water furrows. After the harvest the land is left

covered with a great accumulation of trash, consisting of the cane tops and leaves. This is burned over at the first suitable opportunity in order to kill the cane borer, but more particularly in order to prevent it from clogging the drains and water furrows and thus keeping the land too wet and cold during the winter. This is recognized as a great waste of fertility since so much vegetable matter is destroyed that ought to be reincorporated with the soil. Under these special conditions, however, its advantages are found to considerably outweigh its very obvious disadvantages. It must be remembered that in this short rotation an abundant supply of vegetable matter is returned to the soil every three years with the corn stalks and pea vines. The burning, too, clears the ground for the subsequent cultivation of the stubble cane. In the early spring an implement known as a stubble digger is passed over the rows to loosen up the ground between the stubbles. If the upper buds of the stubble have been injured by the winter, another implement, known as the stubble shaver, may first be passed over the row to cut off these injured tops below the surface of the ground. As soon as the stubbles begin to sprout the rows are barred off, fertilized, rebedded, and cultivated exactly like the plant cane.

The fertilizers used in Louisiana for cane are largely the phosphates though nitrogenous manures are also employed. Potash does not seem to be needed. This is probably to be explained by the well-known fact that the phosphates tend to hasten maturity, a point so important for Louisiana, while

potash has the contrary effect of prolonging the period of vigorous growth.

Most unfortunately for the sugar-cane industry the harvesting as yet has to be done by hand. This requires a much larger force of laborers than the cultivation, and at the present time constitutes the most difficult problem that confronts the cane grower. A successful mechanical harvester is a great desideratum. The great weight of the crop to be handled and the fact that it is usually badly tangled by storms are serious obstacles to be overcome, but the worst difficulty is that judgment has to be used as to the height at which to top the cane in order not to waste it on the one hand by cutting too low or by cutting too high to include immature tops which carry impurities that prevent the crystallization of the sugar. Whether these difficulties can ever be successfully solved remains for the future to decide. A successful machine for cutting cane already exists and it is sometimes employed in windrowing, but ordinarily it is not found to have much advantage over hand cutting. There are now several fairly successful devices for loading cane into carts or wagons, after it is thrown in piles by the cutters and others for transferring it from carts to railroad cars and from the cars to the conveyor at the mill. It is thus seen that cutting and stripping are practically the only hand work remaining in the Louisiana cane fields.

Methods of Cultivation: Hawaiian Islands.—Climatic and soil conditions are exceedingly variable in different parts of the Hawaiian Islands, and cultural

methods must be correspondingly varied. On the moist windward sides of the islands, where there is abundant rainfall, the methods employed are essentially those of Louisiana except that the planting ridges are omitted, since the soils are permeable, but the earth is worked toward the row during cultivation. One row only of seed cane is used and rows are spaced five to six and a half feet apart. In the dry regions on the leeward side, where most of the more important plantations are located, irrigation is needed. This is supplied in some cases from natural streams and in others by pumping. Great attention is given to the proper preparation of the land. Where the nature of the soil will permit, it is broken two or even three feet deep with powerful steam plows and it is very thoroughly pulverized. Planting furrows five feet apart and twenty to twenty-five inches deep are made with large double moldboard plows. The bottom of this furrow is pulverized by a subsoil plow or some special pulverizing implement. Usually the tops of the cane only are used for seed. A single line is placed in the bottom of the furrow, a light irrigation is given, and the seed cane is covered with two or three inches of dry earth by hoes. No general cultivation is attempted nor is it needed in this deeply prepared soil that does not become compacted by heavy rains. After each irrigation a light fresh coating of dry dirt is added with hoes to check evaporation. After the harvest the trash is burned as in Louisiana. On many plantations the earth is now plowed toward the stubble with turning plows, and the subsequent

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irrigation is applied in the water furrow. As a rule only one or at most two crops of stubble cane are harvested, after which the field is plowed up and again replanted. The chief feature of the Hawaiian cultivation is the immense amount of commercial fertilizer used. Practically no cane is planted without it, even on virgin lands, the quantity applied running from six hundred to as high as fifteen hundred pounds per acre. Complete fertilizers are usually employed, and two or even three applications are made during the year. The exact formula used and the method of application varies considerably on the different plantations, but the tendency is to employ a large per cent of potash. No such necessity exists here for forcing early maturity as is found in Louisiana. The largest yields of sugar known in any part of the world are obtained on these highly fertilized, irrigated plantations. They reach more than sixty tons of cane per acre with a sugar production of over eight tons.

Methods of Cultivation: Cuba.—At present Cuba is passing through a transition period in regard to methods of cane cultivation. Formerly cane was planted exclusively on new lands. The forest was cut down, fire was applied to the tangled mass of vegetation, and pieces of cane were planted among the blackened logs and stumps by simply thrusting them into holes made by crowbars. No preparation of the land was attempted and no cultivation was given or required. Sprouts and vines which sprung up were cut down occasionally with the hoe or machete. The soil was originally so fertile and the climate so congenial to cane production that even with this crude

method immense crops of cane were produced for many successive years without the necessity of re-planting. After the cane was harvested the trash was allowed to lie on the ground as a mulch and this was a powerful aid in keeping down weeds and grasses. Such as did appear were chopped out occasionally by the hoe. Such fields continued to yield annual crops of cane without replanting for fifteen or twenty or on very rich lands even for thirty or forty years. There are still forest lands in eastern Cuba where this same system is being followed with the greatest success. In the older sugar districts, however, the forests have long since disappeared and the lands have been plowed and replanted many times. Continued cropping without the use of restorative measures has had its inevitable result. Crops have gradually grown smaller and fields have required replanting at constantly shorter intervals till finally they have been abandoned or used for pasturage. Every old sugar mill is surrounded by thousands of acres of such half-abandoned lands that only require the application of reasonable agricultural methods to again become profitably productive. In the gradual change from the old condition to that which exists at the present time various methods of cultivation have been proposed and more or less extensively followed. None have proved entirely satisfactory and the planters strongly feel the need for improvement. The plan in most general use is as follows: The ground is plowed and cross plowed with large turning plows drawn by three or four yoke of oxen. One man is required to hold the plow, another to drive the oxen, and usually a boy to lead the

front yoke. Such an outfit plows but one third to one half an acre a day, which makes the work very expensive. Usually harrowing is not attempted. Planting furrows are opened with the double moldboard plow and two short pieces of cane are dropped side by side at intervals of about three feet. The cane is covered with hoes. Planting is done either in the fall or spring, but fall planting is considered most profitable. During the first season cultivation is given with small plows or with Planet cultivators and with the hoe. After cutting the first crop the field is treated like new land. The trash remains as a mulch, but as the fields are now thoroughly infested with rank-growing grasses this is not sufficient to keep the land clear. No plowing is attempted on account of the trash, but the ground is all hoed over about three times in the course of the season. This is a heavy expense and still it does not prevent the grass from seriously injuring the cane. The land in these old fields, too, becomes very hard and compact and after a few years the cane roots suffer from want of aération. It is no wonder, therefore, that these old land fields require replanting so much quicker than new land where the soil is left loose and open by innumerable decaying tree roots. This system gives fairly good results for the first crop or so-called plant cane, though it could be improved by the better preparation of the land, the introduction of a leguminous crop before planting, and the intelligent use of commercial fertilizers. It fails badly with the successive crops of stubble cane and thus sacrifices the chief benefit to be derived from Cuba's unusually favorable soil and

climate, that of the production of many crops without the expense of replanting. Some planters advocate giving more space, and plant in hills six feet apart each way, as is usually done on the new lands. They then cultivate both ways the first season. Cane suckers or tillers so much during this long growing season that this plan secures a full crop on strong lands, but it has little or no advantage so far as the subsequent crops are concerned. In fact since a less portion of the land is occupied by cane there is a larger surface to be cleared by the hoe. Dr. Zayas, a well-known Havana physician, has for some years advocated a much wider planting, usually eight by twelve feet, and the continued use of cultivators drawn by animals. His writings contain many half truths, but his system has not proved a commercial success.

The system recently advocated by the Cuban experiment station, while it has not yet stood the test of long-continued use, promises to solve satisfactorily the question of the continued production of profitable stubble crops. It is as follows: Plow the land intended for fall cane in the winter or spring. Plant to velvet beans in April or May. Plow these under with a disk plow in August and September. Harrow two or three times with the disk harrow. In October open deep planting furrows with the sulky double moldboard plow, spacing them about seven feet apart. Scatter tankage and potash or some similar complete fertilizer carrying about equal parts of nitrogen, phosphoric acid, and potash in the bottom of the furrow at the rate of five hundred pounds per acre.

This is best done with a two-horse fertilizer drill. A small cultivator shovel attached at the rear of the drill will serve to mix the fertilizer in the bottom of the furrow. Now drop a continuous row of seed cane in the bottom of the furrow. It is best to select plant cane or vigorous-growing stubble for seed. Using that from old, worn-out stubble fields is unadvisable, as it will make a weaker, less satisfactory growth. Cover with the disk cultivator, setting the gangs to throw more or less dirt according to the condition of moisture. If the ground is moist, germination will be prompter if the cane is not covered more than two or three inches. If it is dry, it is necessary to cover six or eight inches deep to prevent the drying of the seed canes. In from one to two weeks, or just as the first shoots are peeping through the ground, harrow the field thoroughly with the smoothing harrow, running lengthwise of the rows. This will kill any small weeds that may be starting and will freshen the surface of the soil and greatly aid germination. When the young plants are well up so that they show from one end of the row to the other, begin cultivating with the ordinary two-horse riding corn cultivator, of course straddling the row so as to cultivate both sides at once. The seven-foot rows are so wide that there will be a strip in the middle not reached by the cultivator. This can be finished with an ordinary walking cultivator of the Planet Jr. type, or the narrow cultivator blades may be removed from the regular cultivator and eight-inch cutaway sweeps be bolted on instead. These will have a wide enough cut to meet in the center and as thus

rigged the same implement makes a good middle cultivator. Cultivation should be repeated throughout the winter as often as is needed to keep down all weeds and maintain a dust mulch. Before spring the growth of the cane will be so great that the row can no longer be straddled and the middles only can be cultivated. In April or the first of May sow cowpeas broadcast in the middles, cover them with the cultivator, and the work is finished. Up to this point the plan does not differ materially from the ordinary system except that the use of the riding corn cultivator which works so close to the row makes it possible to almost completely dispense with the expensive hoe. It is only the few weeds and bunches of grass that come up directly in the row among the cane that have to be cut with the hoe or better still be pulled by hand. The line of cultivation thus outlined will leave the land practically level. This is right for the red lands since they have natural underdrainage, but in the wetter black lands it should be modified by using disk cultivators which ridge up the row as in Louisiana.

As soon as the cane is cut, take an ordinary horse hayrake and drive so as to cross the cane rows, raking the trash from one middle and dumping it in the next one. This quickly and cheaply clears half the ground so that it can be plowed and cultivated, and it provides a double mulch of trash for the other half which makes it so thick and heavy that practically no grass or weeds can come through, and these middles will require no further attention for the season. Now plow the cleared middles with a two-horse

turning plow, throwing the dirt away from the cane. Run the last furrow up as close to the cane stubble as possible. You will not hurt the roots. They all died when the cane was cut, and new ones will form as the new shoots of cane begin to grow. If fertilizer is needed, it can now be applied in this open furrow next the cane. On most lands, however, it will only be necessary to use fertilizers every third or fourth year. Do not leave the furrow next the cane open any longer than is necessary, but work the dirt back with the cultivator, using some implement that will throw a little dirt back over the stubble. Keep these alternate middles well cultivated until the beginning of the rainy season and then sow them down to cowpeas. This will be found much cheaper than the ordinary plan of going over all the surface of the ground two or three times with hoes, and it leaves the stubble cane in even better cultural condition than the plant cane, for one side of each row is thoroughly cultivated, while the other side is protected by a heavy mulch of trash, that serves perfectly to retain moisture. The next year, of course, the middles are reversed so that all the soil is thoroughly aerated, and pulverized every two years. And yet only half of it is exposed to the depleting influence of tillage, while all the trash is retained on the land and is ultimately incorporated with it to add to its supply of humus, a substance so necessary for successful tropical agriculture. Another great advantage of this system of promptly raking the trash and plowing alternate middles is that each such plowed strip makes an efficient

fire break, and by properly spacing the early cuttings much can be done to safeguard the cane fields from fire, which is an enemy more dreaded than any other by the Cuban planter. As stated before, this system has not as yet been tested for a long term of years, but it is giving most excellent results, not only in decreasing cost but in increasing production, and it promises to do much to prolong the productive life of the cane fields. It is the only system of cane cultivation that has ever satisfactorily solved the troublesome question of the proper and economical disposition of the trash ; and it seems to promise that Cuba will continue to be in the future, as it long was in the past, the country of cheapest sugar production.

Methods of Cultivation: Other American Countries. — The sugar business is an old established industry in most of the other tropical American countries. In all of them, however, the tendency is to cling too closely to old methods of hand labor. Even in Porto Rico, where the business is now largely in the hands of American capitalists, workmen may be seen laboriously opening deep holes for planting cane with the hoe, and this, too, on lands that are perfectly adapted to the use of the best implements. The same dependence on the hoe or machete is to be found in all of these other countries. This is not so much due to lack of knowledge on the part of the owners as it is to the supposed difficulty of teaching the native laborers the use of improved implements. This, it must be admitted, is often a difficult task; but that it is not impossible is shown

by the results on those plantations where it has been most faithfully and intelligently tried, and nothing is more certain than that those countries where the owners fail to teach their laborers this added efficiency will be inevitably forced out of the sugar business by the irresistible competition of those who succeed in so teaching them.

Botanical Features and Varieties. — The flowers of sugar cane are produced in a long showy terminal panicle, somewhat as in the various sorghums. The flowers are perfect, and yet but few seeds are ordinarily produced. In subtropical regions cane seldom flowers, and never produces seeds. It is propagated entirely from the buds which are produced at every joint on the stalk. The stalks are either laid down and covered with earth, or the tops are cut off and stuck in the ground as cuttings. In recent years, however, especially in some of the British West Indian colonies, much attention has been given to planting the seed of sugar cane for the purpose of originating new varieties, hoping in this way to find some with a greater sugar content, or a greater resistance to disease than those now in general cultivation. Many thousands of seedling canes have been produced in Barbados and Demerara, and among them a few have been selected that seem quite superior, and are being planted on a considerable scale. The great majority of the seedlings are, however, inferior to the parent varieties.

Many quite distinct varieties exist in different parts of the world, and the problem of collecting them and testing them under local conditions is

everywhere receiving the attention of experimenters. Great confusion exists in regard to the names of these varieties, since the same kind has often received different names in the various countries to which it has been introduced. This active comparative study of varieties, and the production of so many new ones, will, it is hoped, soon lead to an improvement in the average sugar content, as has been done in so marked a way by similar work with the sugar beet. Meanwhile it is interesting to note that the industrious Dutch investigators in Java have recently conclusively demonstrated the complete practicability of largely and permanently increasing the sugar content by the chemical selection of the best strains found in existing varieties. The practical importance of this discovery is greatly enhanced by the fact that increased richness in the juice seems to be correlated with large size and vigor in the cane. This fact seems to have been proven by long-continued and extensive breeding experiments. If it shall be confirmed by further experimentation in other countries, it will prove a discovery of the utmost practical importance, since by simply persistently selecting the most vigorous, heaviest canes for planting, year after year, we will not only develop a strain yielding a greater tonnage, but one yielding a considerably richer juice as well. The importance of a careful selection of seed cane is a question that has been grossly neglected in most cane-growing countries.

Diseases and Insects. — The cane borer (*Diatrea saccharalis* Fabr.) is a lepidopterous larva that is

rather widely distributed in cane-growing countries. It bores into the stalks, forming irregular galleries. It also attacks corn and some of the other large grasses. When sufficiently abundant, it is capable of doing serious injury, but for the most part it seems to be kept in control by natural enemies. The principal remedy, when one is needed, consists in burning the trash as soon as the cane is harvested.

A mealy-bug is frequently found abundantly on sugar cane. It lurks under the loosely fitting leaf sheaths, and undoubtedly causes considerable injury from sucking the juice. It has not, however, attracted much attention, and no remedial measures have been proposed.

One of the army worms (*Heliothis unipuncta* Haworth) sometimes causes damage in Cuba by eating the leaves from the young canes. It is not often very troublesome, and no remedies have been tried. Dusting with Paris green and the use of poisoned baits, as for cutworms, could be resorted to if necessary.

The sugar-cane leaf hopper (*Perkinsiella saccharicida* Kirkaldy) was accidentally introduced into the Hawaiian Islands some years ago from Australia, with some varieties of seed canes that were brought in for experimental purposes. Being free from the presence of the native insect enemies that have always kept it under control in Australia, it multiplied with great rapidity, and for a time threatened serious injury to the sugar industry. The experiment-station entomologists, however, succeeded in importing successfully some of its Australian insect

parasites. They, in turn, are now multiplying rapidly, and it seems probable that they will succeed in checking the increase of the leaf hoppers.

In Barbados and some of the other Lesser Antilles much loss has been occasioned by a root rot of the cane caused by a minute parasitic mushroom (*Marasmius sacchari* Wakker). What is supposed to be the same disease has also recently been reported from Hawaii. Some of the new seedling varieties of cane seem to have considerable immunity to this disease and their use is recommended for these infected regions.

In Cuba the Marasmius disease has not been detected, but a similar root rot is caused by an undescribed species of *Peniophora*. This fungus is normally a saprophyte that forms mats of white mycelium in the old leaf sheaths near the ground and on the old dead stubble. Under some conditions, however, it invades the living tissues, killing the base of the stalks and the roots. It has not attracted much attention and no remedies have been tried, but it occurs very abundantly and is doubtless one of the principal causes for the dying out of the old cane fields.

A bacterial top rot of the cane also occurs in Cuba. Whether it is the same as the one that has been studied in Java has not been determined. It involves the soft tissues surrounding the terminal bud, which it soon kills, thus causing the death and drying up of the whole cane. It occurs very commonly in old fields that are in bad condition. It is known locally as the "drying" of the cane and it

annually causes very considerable losses. It is usually the determining factor that necessitates the plowing up and replanting of the old fields. Fortunately vigorous, rapidly growing canes have great powers of resistance to this disease and are very seldom attacked. The intelligent use of fertilizers and cultivation may be depended on as an absolute specific for it.

The rind disease (*Melanconium sacchari* Wakker) is everywhere present in cane fields. It is easily recognized by the black horn-shaped masses of spores that protrude from little pustules under the cortex and conspicuously roughen and blacken the infected areas. The fungus is normally a saprophyte, living on the dead cane tissues, and it cannot unaided penetrate the epidermis of the healthy cane. Whenever this is wounded, however, by any cause, it is able to gain an entrance, and it often causes great damage in connection with or as a secondary effect from some of the insects and diseases mentioned above. This is particularly true of the leaf-hopper injuries in Hawaii and the top-rot disease in Cuba. Canes infested by the latter are quickly invaded by the rind disease also.

The dreaded Surah disease of Java has not yet been found in America. The greatest care should be observed in importing canes from the East for experimental purposes lest this or other serious pests be imported with them. This danger is well illustrated by the case of the leaf hopper in Hawaii. In fact it is so great that the transportation of cane from one country to another should be strictly pro-

hibited by law except when it is done by properly accredited government experiment stations, where all possible precautions can be taken and where the growing cane can be constantly under the observation of experts.

THE GRAINS

Corn (*Zea Mays L.*)

For the region that it is intended to cover by this work, corn must be regarded, taking everything into consideration, as the one most important crop, notwithstanding the fact that the corn belt proper is not included in our limits. Few cultivated plants have as wide a range of distribution and few equal it in the number of uses to which it is put in the world's industries and in local utility on the farm. It is the greatest gift that the new world has given to the old. Although a native of warm climates it can be grown successfully as far north as southern Canada and in fact in practically all temperate and tropical regions where there is sufficient rainfall for three or four months in the year. Very dry air prevents proper pollination, so that it does not succeed well as a rule in regions entirely dependent on irrigation.

Climate and Soil. — Corn requires a period of at least three months of continued warm weather with warm nights and frequent though not excessive rains. It will grow on almost any well-drained soil that can be put in good mechanical condition. It thrives best on deep loamy soils that contain a mixture of both sand and clay combined with a large amount

of vegetable matter. Well-drained alluvial soils along streams and the rich black prairies of the middle West are exactly suited to its requirements. No crop responds more readily to the use of fertilizers and improved methods of preparation and cultivation, and on the other hand none will endure more abuse and neglect without inviting absolute failure.

Manuring. — Corn is a gross feeder and can utilize manurial substances in almost any form. An abundance of vegetable matter is a necessity for the production of maximum crops. Of the three elements usually bought in fertilizers, nitrogen is doubtless the most important and it is the one that is usually soonest exhausted under continued cropping. In the South, however, with the system of cultivation detailed below, this need never be purchased, but can be grown on the ground by means of a leguminous cover crop. This is one of the greatest advantages coming from the longer growing season at the South. The vigorous growth of the stalk depends very largely on the presence of sufficient nitrogen.

Phosphoric acid is, however, almost equally important, for without it there will be a scanty production of grain. This cannot be produced on the farm, but must be purchased. In most parts of the South it can be secured cheapest in the form of acid phosphate, which is a ground phosphatic rock that has been treated with sulphuric acid to make it more soluble. The use of two hundred to three hundred pounds per acre of this substance will prove profitable on nearly all Southern corn lands that have been long in cultivation. On the pine lands it is indispensable from

the first, since these soils are exceedingly deficient in phosphoric acid.

The need for potash is in most cases less evident. Most Southern soils contain enough of this substance for the present need of the corn crop and it should only be applied when the need for it has been demonstrated by actual experiment. For corn the muriate of potash will answer as well as the more expensive sulphate.

Corn endures a certain amount of acidity in the soil with very little harm. It is seldom, therefore, that liming is necessary for this crop.

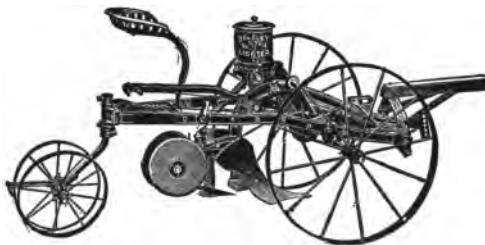
Methods of Planting and Cultivating.—In the Northern corn belt planting is mostly done with two-horse check-row planters. These implements drop two rows at a time, and by an ingenious device the hills are so spaced that they will row in both directions, thus allowing cross cultivation. The distance between hills is usually about three and a half feet, though this varies in different localities. Before planting, the ground is plowed and thoroughly harrowed. If the land was in corn the season previous, an implement known as a stalk cutter is run in advance of plowing, which cuts the stalks up in short sections so that they will not interfere with plows and cultivators. As soon as the corn is above ground or even earlier, if there has been a rain to pack the surface, a smoothing harrow is passed over the field with the teeth set at a considerable angle, so that they may not tear out the young plants. These, being slightly below the surface in the planter furrow, are seldom injured, but the surface of the ground is stirred and

mellowed and young weeds are destroyed. As soon as the corn is five or six inches high the use of the two-horse cultivator is begun. This straddles the row, cultivating both sides at once. The cultivators are now kept running constantly, first in one direction and then in the other, until the corn is so high that it can be no longer straddled without injury. By this time it shades the ground so completely that no further work is necessary. This system is perfectly applicable in the South, and all lands that have good drainage, and yet that are level enough to admit of cultivation in both directions without danger of loss from washing, might well be planted in this way. Cowpeas, at the rate of three to six pecks per acre, should, however, be broadcasted among the corn, just in advance of the last cultivation, or a continuous row may be planted in each middle with a one-horse cotton or corn planter.

On very wet lands like the Louisiana sugar lands it is necessary to plant the corn on elevated beds, as has been described for sugar-cane planting. This does not admit of cross cultivation and the two-row planter cannot be used. It is usual to give rather more space between the rows, usually four and a half to five feet, and to plant with a one-row planter arranged to drop one to two seeds every twelve to eighteen inches. This gives almost as many stalks per acre, and the greater width between the rows allows a better opportunity for the growth of the cowpeas. On such lands peas should be broadcasted, as they will not thrive if planted in the water furrow.

On most of the Southern uplands the surface is so

rolling that terracing or circling the rows (planting on contour lines) is necessary to avoid serious loss from washing. This, of course, also makes cross cultivation and the use of the check-row planter impossible. On these light hill lands it is also found best to space the rows about five feet apart, but to drill in the cowpeas in a single row in the middles. This makes it possible to cultivate once or twice after the peas are planted, which is a great advantage, since maintaining a dust mulch as late in the season as possible is of the utmost importance on these lands, which otherwise suffer so quickly from short periods of drought.



A Lister Corn Planter.

In the drier regions west of the Mississippi River the system of listing corn, that is, of planting it in the bottom of deep water furrows, has come to be widely adopted. This is exactly the reverse of the Louisiana system, where it is planted on top of the beds. The land is either first broken flat with a common plow and then planting furrows opened with the double moldboard plow or, if the soil is of friable texture, the planting furrows are opened between the old rows without previous plowing. Lister planters

are now in use that open the furrow and plant the seed at one operation. Special narrow cultivators have also been devised that work in the sides of these deep lister furrows, gradually filling them as the plant grows, so that when laid by, the land is left nearly level. This system is excellent for the special conditions where it has been developed and it might be profitably used much more widely, especially in tropical countries during the dry season. It would be admirably adapted to such soils as the Cuban red lands that have such remarkable natural drainage.

Not so many years ago corn was all planted by hand. The farmer opened a shallow furrow with the plow, girls and small boys dropped the seed, and it was covered with hoes. When the grass and weeds got high enough to be in danger of hiding the row, it was "barred off" by running a one-horse turning plow with the bar to the row, thus piling up the dirt in the middles. The row was next cleared with the hoe, and two or three weeks later it was "laid by" by plowing the dirt back to the row and ridging it up as much as possible. This would now be considered barbarous treatment, and it is no longer seen except in some modified form on rough new stump lands where no other method is possible, and yet such is the natural vigor and bounty of the corn plant that our fathers and grandfathers usually contrived to keep full corn cribs before check-row planters and two-horse cultivators were even dreamed of. The once almost universal custom of "barring off" the young corn is now considered under ordinary circumstances to be quite harmful, since it unduly exposes the soil

near the roots of the plant to the drying action of wind and sun. There are times, however, when a newly planted field has been deluged by long-continued cold rains, that this old treatment is clearly indicated as the best means of warming and drying the soil. The furrows should be filled, however, as soon as this purpose has been accomplished.

Harvesting.—In the corn belt proper on those farms where this is the principal money crop it is usually only the grain which is utilized, the stalks and leaves being allowed to go to waste in the field. When the corn is fully dry, wagons are driven into the field; the ears are husked by hand as they stand on the stalks and are thrown in the wagon. When this is full, it is driven to the cribs where the ears are temporarily stored or direct to the corn sheller. When shelled, the corn is shipped in bulk to elevators, where it is stored, or it may be sacked for retail shipment.

In the South corn is usually only grown as a subsidiary crop for home use in the feeding of animals. Since the stalks and leaves if properly harvested contain, roughly speaking, as much stock food as the ears, it becomes a matter of considerable importance to see that they are properly utilized. It is a common practice in many parts of the South to strip the leaves from the stalks at the time that the corn is beginning to harden. These "blades," as they are called, are tied in bundles and, when dry, are carefully housed and make most excellent feed for horses and mules. They are a great resource for the small farmer of the South. Stripping the blades requires

a considerable amount of expensive hand labor, and careful experiments show that the practice reduces the yield of grain from two to three bushels per acre. Sometimes also the tops above the ear are cut and shocked until dry. The Northern practice of cutting and shocking the entire stalk, afterwards shucking out the ears and utilizing the stover as fodder for cattle, is but little practiced at the South. This is perhaps partly on account of the heavy winter rains which injure the shocked corn and fodder, but the falls at the South are usually dry enough so that a large amount of the crop could be utilized in this manner. The silo for preserving green corn fodder is but little used at the South.

All of these methods, however, require a considerable amount of laborious and expensive hand labor. With the perfection of modern machinery it is now possible to avoid this and to handle a corn crop very economically and so as to secure from it the fullest possible food value. The crop is allowed to get a little more mature than is usual for cutting and shocking. It is then cut with a corn harvester which ties the stalks in small bundles. These are set up into shocks to cure, and when thoroughly dry they are hauled to the barn and are run through a shredder. This machine slits the stalks up lengthwise into thin shreds, in which condition the entire stalk is readily eaten by cattle. At the same time the ear is snapped off by the machine and is husked and shelled, the cobs coming out of one opening and the shelled grain at another. This almost entirely does away with hand labor in harvesting and storing the corn crop,

and it makes the entire plant, with the exception of the cob, immediately available for stock food.

Chief Uses. — The chief use of corn is unquestionably as food for domestic animals and, as we have just seen, the entire plant may be utilized in this way. The grain is also an important article of human food. It is used in the arts for the manufacture of starch, of glucose, of oil, and in the preparation of fermented and distilled liquors.

Botanical Features and Varieties. — Corn, like sugar cane, belongs to the great grass family. It bears staminate flowers on a terminal panicle called the tassel, while the pistillate flowers are borne in one or more compact axillary spikes called ears, each of which is covered with a number of closely appressed bracts, the husks. The corn silk consists of the greatly elongated stigmas, one of which runs down to each kernel. The pollen from the tassel falls on these hairlike stigmas and the pollen tube grows down to and fecundates the egg cell located in the immature grain.

The number of recognized varieties is very great, but they may be grouped under a comparatively few races. The principal of these are the dent corns, the flint corns, the sweet corns, the flour corns, or horse-tooth corns as they are sometimes called, and the pop corns. The dent corns are by far the most important and constitute the great bulk of the corn of commerce. There are many varieties, white, yellow, or red in color. The most typical varieties have white grain and white cobs. The flint corns, as a rule, have a shorter growing season than the dent

varieties, and hence can be grown somewhat farther north. They are extensively grown in New England and Canada. Some of the varieties are also very hardy under tropical conditions. The ordinary dent corns fail entirely when planted in Cuba, but the native corn, which is a yellow flint variety, thrives and yields fair crops. The flint corns are usually yellow, though white and bluish varieties also occur. The flour or horse-tooth corns are mostly grown in the uplands of Mexico. They have very large soft white kernels that are easily beaten into meal in the rude native mortars. They are grown somewhat in the Southern states, especially for fodder, but they have little commercial importance. Coming from the Mexican uplands, they thrive no better in Cuba than the Northern dent corns. The sweet corns so universally planted at the North for table use and for canning are comparatively little known at the South. They can be grown successfully in all parts of the Southern states and should be much more widely planted, as they are so superior for the table. The fodder, too, is greatly relished by cattle and horses. Unfortunately they cannot be grown in Cuba. The pop corns are of comparatively little importance and yet they can hardly be omitted from the household resources.

During recent years notable progress has been made in improving varieties of corn. Not only have strains been developed that give largely increased yields, but very notable success has been achieved in selecting strains that are especially adapted for different purposes. It has been demonstrated that

by careful selection it is perfectly possible to secure strains in which the kernels run much higher than the average in either starch, protein, or oil, thus adapting the grain much better to the different purposes for which it is used. For starch, glucose, and distilled liquors a high starch content is desirable. For feeding purposes a high protein content is best, and for the manufacture of corn oil a high oil content is, of course, desired. We are only just beginning to realize how plastic most of our more familiar farm crops are and how possible it is to greatly improve them in almost any desired direction simply by careful attention to the selection of the seed.

Diseases and Insects. — Corn is subject to a considerable number of diseases, but the smut is the only one of sufficient importance to be considered here. The unsightly black spore masses of this fungus are familiar objects in every cornfield. It may attack almost any part of the plant, but it is usually found involving the ears and it is only here that any serious damage is done. The number of smutted ears varies greatly in different fields and in different seasons, but it seldom exceeds two or three per cent. Even this small percentage represents in the aggregate an enormous loss. Corn smut cannot be controlled by treating the seed, as is the case with the various smuts of the small grains. The only known remedy is to hand pick and destroy the young pustules before they burst and scatter the multitude of black dustlike spores. Even this will not prove an entire preventive, since these spores are so light

that they can easily be carried long distances by the wind.

The number of insects seriously attacking corn is very great, so many, in fact, that a full discussion of them cannot be attempted in a general work of this kind. The reader is referred to the comprehensive work on corn insects recently issued by Professor S. A. Forbes, entomologist of the Illinois Experiment Station.

Rice (*Oryza sativa* Linn.)

In the Oriental countries rice occupies the same commanding agricultural position that wheat and corn do with us. It has long been grown to some extent in certain parts of South Carolina and Louisiana. During recent years it has come to be very largely planted on the low plains of western Louisiana and eastern Texas. It is also grown in a small way in all parts of tropical America, but aside from the regions just mentioned its cultivation has not received the attention which the importance of the crop deserves.

Rice is very largely used in the Southern states, and especially in Cuba and the other West India islands. Large areas of lands suitable for its culture are to be found in these islands, but so little attention is paid to this crop that by far the greater part of the rice consumed is imported.

Chief Uses.—The chief use of rice is for human food. In preparing the grain for market two by-products are secured, known as rice bran and rice

polish; these are extensively used for feeding hogs and cattle.

Upland rice, a variety adapted to dry soils, is grown on a small scale for local use throughout the Gulf states. This is often cut before fully mature, and is bundled and cured the same as oats. It is fully equal to sheaf oats for feeding horses. No other food puts them in better condition or gives them a glossier coat.

Climate and Soil. — Rice is a crop of warm countries, although there are varieties that are grown successfully in northern Japan. The crop requires abundance of heat and moisture. Most of the kinds require irrigation. The plant is semiaquatic and will endure flooding for considerable periods. The best rice soils are rather stiff clay, containing plenty of vegetable matter. Reclaimed swamps and marshes are usually adapted to rice. The upland kind before mentioned will grow on any soil suitable for corn or cotton.

Manuring. — As a rule but little attention is paid to manuring rice lands. Applications of phosphoric acid would, however, in many cases be profitable, owing to the increased yield of grain.

The small farmers of the pine-wood regions of the South usually plant their upland rice on cow-penned land.

Methods of Planting and Cultivation. — In Eastern countries rice is planted in seed beds, and the young plants, when several inches high, are transplanted to the freshly irrigated fields, laborers often wading to their knees in performing the operation. This

method would be far too costly with our high-priced Western labor.

The rapid extension of rice growing in Texas and Louisiana has been due to the discovery that on these soils it is possible to plant and harvest rice by machinery in exactly the same way that wheat and other small grains are handled at the North. Fields are arranged with a system of dikes and ditches so that they may be flooded at will. The land is plowed and harrowed the same as for any other grain crop, and seed planted with a grain drill.

If the ground is moist enough to insure germination, no irrigation is given until the plants are several inches high; then the fields are flooded and the water allowed to remain long enough to kill the young weeds and grass. The water is then drawn off and applied again at intervals as needed. As the grain matures the fields are thoroughly drained in order to admit of the use of self-binders for harvesting the crop.

The grain is thrashed in the same manner as wheat or oats, but as the chaff adheres very closely to the kernel, this rough rice, or *paddy*, has to go through a milling process before being ready for market.

The upland rice, grown in small quantities by so many Southern farmers, is not irrigated and consequently must be cultivated two or three times in order to keep down grass and weeds. It is usually planted in drills about twenty to twenty-four inches apart, which is sufficient space to allow for cultivation with a single shovel plow.

Botanical Features and Varieties. — Rice like the

other grains belongs to the great grass family. The seeds are borne in a terminal panicle in much the same manner as oats. Comparatively few varieties have been grown in the United States, but in Japan and other Eastern countries a great number are recognized. The Honduras rice, formerly so largely grown in Louisiana and Texas, had a soft kernel which broke badly in milling, thus occasioning considerable loss. Through the efforts of the Department of Agriculture a superior kind has been imported from Japan, which has a grain hard enough to resist the milling machinery, and the loss from broken grains is thus avoided.

Diseases and Insects.—So far rice has been comparatively free from troubles of this kind. A few years ago a rice smut was imported into South Carolina from Japan, but has only been locally troublesome. Such other troubles as occur have attracted but little attention and have not been exhaustively studied.

Oats (*Avena sativa* Linn.)

Oats are grown with more or less success in all parts of the Southern states, and can even be grown, as a winter crop, on some soils in Cuba. They do best at the South when planted in the fall, although they are occasionally injured by exceptionally severe winters. Fall-planted oats may be pastured throughout the winter, when the ground is not too soft, and will still make a fair crop of grain, though yields at the South are never as large as at the North. In fact they are usually planted quite as much for the pas-

turage they afford as for the grain. Oats have been quite widely recommended as forming a part in a well-considered rotation for the upland cotton farmer. The rotation generally suggested is cotton followed by corn with cowpeas between the rows; these are plowed under in the fall and the land is immediately seeded to oats. After the oats are harvested cowpeas are again planted, to be followed by the cotton the next spring. The variety known as Texas rust-proof oats is most widely planted at the South, and the turf or grazing oat is also popular.

Rye (*Secale cereale* Linn.)

Rye is considerably sown at the South for winter grazing, for winter cover crops in orchards, and other similar purposes. Best results are usually obtained with home-grown seed. There are certain strains which have been long grown in the South that give better results than Northern seed. In Cuba much better results were had with Florida seed than with that grown even as far north as Georgia. Rye is a crop of minor importance at the South, and should perhaps be included among the forages rather than the grains. The practice of planting it for a winter cover is to be commended, since it is quite effective in preserving the soil from the damage caused by the heavy rains. When plowed under in the spring, it rots quickly and serves to add a certain amount of much-needed humus to the soil.

Millets and Sorghums

A number of kinds of millets are widely grown as subsidiary crops in the Southern states. They also

should be classed as forage plants, since, as a rule, they are utilized fully as much for green forage as for the grain.

German millet (*Setaria Italica Germanica*) is sown as a hay crop in the more northerly portions of the Southern states; it is seldom seen in the lighter soils of the Gulf region.

The pearl millet (*Pennisetum typhoideum*) is often planted in small patches for use as a soiling crop. When cut, this suckers from the roots and yields successive cuttings.

A number of different sorghums are considerably grown in all parts of the South and also in Cuba and other tropical countries. In the drier regions of the Southwest they replace corn, and constitute the principal grain and forage crops.

The sorghums are usually grown in drills, three or four feet apart, and are given much the same cultivation as corn. Sometimes, however, the seed is sown broadcast and the crop is cut and harvested like hay. Some varieties sucker from the roots when cut and thus give two or more crops from a single planting.

The sorghums may be roughly divided into two classes, the saccharine and non-saccharine. Besides their use as a forage, the stalks of the former yield a sweet juice which is used for making a table syrup in those regions where sugar cane cannot be successfully grown. Persistent efforts were formerly made to manufacture sugar from sorghum; the juice contains sufficient sucrose, but also contains impurities which prevent free crystallization, and these attempts have not been commercially successful.

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The early amber and early orange are two of the best of the saccharine varieties. The non-saccharine sorghums are usually grown as grain crops, though they are also used as green forage. Milo maize and Kaffir corn are two of the best varieties. They are now extensively grown in the dry regions of the Southwest, on lands that were formerly considered only fit for grazing purposes. The yield of grain is quite large, and it proves to be nearly equal to corn for feeding all kinds of domestic animals. It is especially valuable for poultry.

PASTURE AND FORAGE CROPS

A much larger number of pasture and forage plants are available at the South than are familiar to the Northern farmer. This, together with the mild climate and long grazing season, makes this region, as a whole, particularly well adapted to the raising of cattle and other domestic animals. Curiously enough, however, there are few parts of the South where this industry has received the attention which it merits. Trainloads of beef, butter, cheese, lard, and bacon are constantly moving southward from the North and West to supply people who could raise these commodities cheaper than those from whom they buy them.

For the enterprising stockman almost all parts of the South present an inviting field. Among the many available forage and pasture plants only the most important will be briefly noted.

Crab Grass (*Panicum sanguinale*).—This grass springs up as a weed in cultivated fields; in fact, it is

one of the worst weeds that the Southern farmer has to contend with.

At the same time it is one of the most valuable grasses for hay and pasture. When corn or other similar crops are laid by in most parts of the South, this grass quickly springs up and occupies the land for the remainder of the season. If the corn is cut and shocked, the crab grass can, a little later, be cut for hay. It cures easily, and if cut before overripe and properly cured, it makes a hay of which stock of all kinds are very fond, and which seems to be nearly or quite equal to timothy in feeding value.

It is greatly relished by stock when fresh, and it is a



common practice to utilize the cornfields for fall pasturage.

Bermuda Grass (*Cynodon Dactylon*).—This is pre-eminently the best Southern grass for permanent pastures. It thrives on all kinds of soil and stands the closest grazing without injury. It is very nutritious

and is greatly relished by stock of all kinds. An acre of Bermuda grass on good land in any of the Gulf states will, on account of the longer growing season, furnish more pasturage than the best acre in the famous bluegrass regions of Kentucky. The one drawback to its more general use is that it is very difficult to exterminate and becomes a serious pest when the land is brought under cultivation.



Bermuda Grass.

It is practically the only suitable grass in the South for lawns, as it covers the ground quickly, and if well enriched and kept closely clipped will make a beautiful sod in a very few months' time. On thin lands it does not grow tall enough to yield profitable cuttings for hay, but on rich lands it will yield a ton or more of very nutritious hay at each cutting, and can be cut as many as three times in the course of the season.

Bermuda grass occurs in all the West India Islands and in the other American tropics. Its value as a pasture grass in those regions has been

largely overlooked, owing to the ranker growing Guinea and Para grasses, which are there so abundant. Bermuda grass is sometimes grown from seed, but the vitality of the seed is not always good, and a stand is often hard to secure in this way. It is a much more certain method to plant bits of sod. These small pieces are dropped into every other furrow, when the land is plowed. After plowing the land is smoothed with the harrow, and unless the weather is unusually dry a perfect stand will be secured. The tufts of grass which spring from these pieces of sod soon spread and completely cover the ground.

Johnson Grass (*Sorghum Halepense*).—This coarse-growing grass was introduced into the South many years ago as a forage plant. It has proved to be a pernicious weed. It spreads by fleshy underground stems, which cannot be killed by any ordinary cultivation and which are easily carried to different parts of the field by plows and cultivators. It grows so rapidly that it quickly smothers crops, and when present in a field necessitates double the usual amount of cultivation.

There are large areas in central Alabama and Mississippi where cotton growing has been given up on account of the presence of this pest. It is



Johnson Grass.

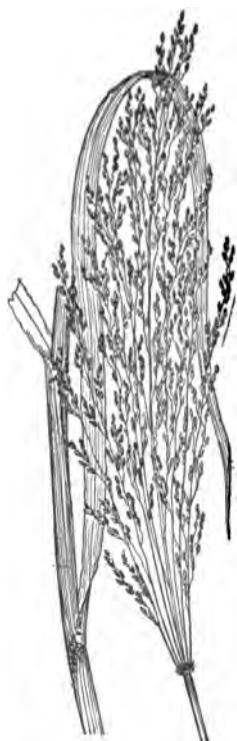
so troublesome and dangerous a plant that its planting for forage is never justifiable. Those planters who, however, are unfortunate enough to have it find that it makes a fairly good though coarse hay, and the abandoned fields before mentioned have been converted into hay farms. The yield of hay is large at each cutting, and it gives a number of cuttings in the season.

As a pasture grass it is not desirable. Cattle and horses do not relish it when green, but learn to eat it in the absence of better grasses. It does not stand trampling well and if heavily pastured will soon run out, though unfortunately it can never be exterminated in this way. On plowing the field it springs up again, as strong and rank as ever.

This grass occurs as a great pest in most tropical countries.

Guinea Grass (*Panicum maximum*).—This is the best of the tropical forage grasses. It grows as rapidly and is as rank and coarse as Johnson grass, but is

very nutritious, and stock of all kinds eat it greedily. It requires a rich and rather heavy but well-drained soil. Under these favorable conditions it grows six or eight feet high and yields an



Guinea Grass.

enormous quantity of forage. It forms large stools or tussocks, and stands grazing perfectly. The famous grazing lands of central and eastern Cuba and western Jamaica are largely set to this grass. It grows much more rapidly during the rainy season, but furnishes considerable pasturage throughout the year. It is estimated that from one and a half to two acres of good Guinea grass pasture will support an animal the year round. Guinea grass does not stand much freezing, so in the United States it can only be grown in Florida and along the Gulf coast. It is propagated either by seed or by sets made by division of the large stools.

When the land is required for cultivated crops, its manner of growth makes plowing difficult; but when the sod is once turned over it soon dies and gives no further trouble.

Para Grass (*Panicum molle*).— This grass is also known as Paral, Parana, Panama, and various other local names. It is a native of South America, but is now found widely distributed. It equals or exceeds Guinea grass in rapidity of growth, but instead of growing in stools sends out long, half-prostrate stems that root at the joints, forming a dense, tangled mass, with free, erect ends which reach a height of four to six feet. It grows in moister land



Para Grass.

than Guinea grass, and will endure submergence for quite long periods. It is eaten greedily by stock and yields an immense amount of pasturage, especially on wet, swampy lands. When the land is plowed, each buried stalk grows, sending up new shoots from the joints like a gigantic *quack* grass. This makes it very difficult to subdue, though it can be killed by repeated plowing during dry weather. It was introduced into Cuba as a pasture grass, but has become a great scourge in the cane fields, especially on the low, black lands. Like Guinea grass it does not endure cold.

Water Grass (*Paspalum dilatatum*).—This is a native of the Southern states. It forms clumps,



Water Grass.

usually in creek bottoms and other wet places, but will grow well on any ordinary farm land. It is much relished by live stock and furnishes a large amount of pasturage for a very long season.

It grows tall enough to make a large yield when cut for hay. It is one of the most valuable of the native Southern grasses, and deserves to be much more widely planted. It is sometimes difficult to secure

good seed, as it is often attacked by a fungus.

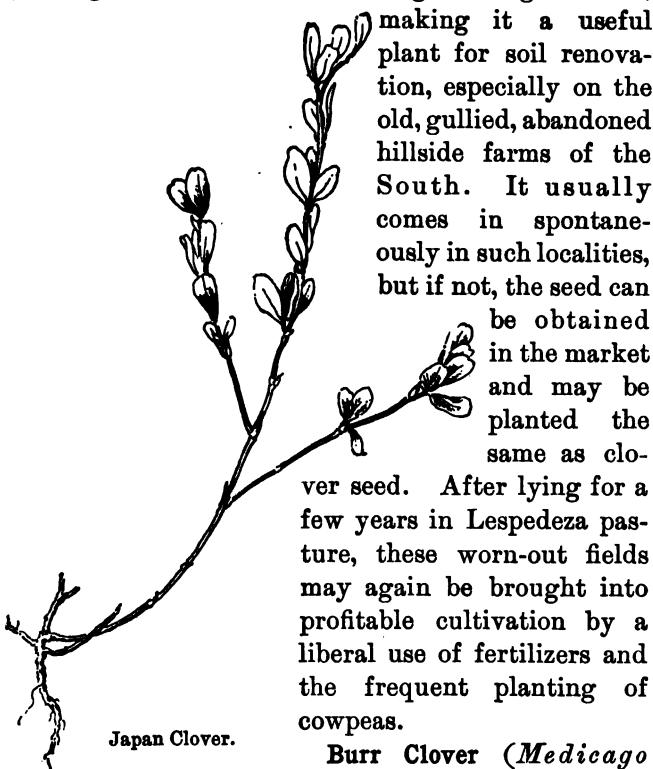
Carpet Grass (*Paspalum compressum*).—This

also is a native of the Southern states, where it is mostly confined to moist, sandy lands. It is a low creeping grass which forms a dense sod when heavily pastured. Carpet grass and Bermuda grass are the only two grasses that serve for permanent pastures on light, sandy soils in the Gulf states. It seeds freely, but is seldom or never planted, coming in of its own accord where land is so heavily pastured as to kill out other vegetation. It stays green throughout the winter and furnishes grazing for twelve months in the year. It does not grow high enough to cut for hay.

Mexican Clover (*Richardsonia scabra*).—This plant has no right to the name of clover; it is an annual weed of cultivated fields, belonging to the Madder family, the *Rubiaceæ*. It is a native of tropical America, but is now widely introduced throughout the Gulf states. Like crab grass it comes up in the fields after the crops are laid by and affords good grazing or yields a heavy cutting of nutritious hay. It is usually found only on light, sandy soils.

Japan Clover (*Lespedeza striata*).—This plant was introduced into the Southern states during the Civil War, presumably in forage. It is now abundant throughout the South, and extends as far north as southern Illinois. It is a low-growing, prostrate annual, coming up late in the spring along roadsides and in pastures and waste places. It is eagerly eaten by live stock, and for two or three months furnishes abundance of nutritious pasturage even on lands too poor and dry to support the ordinary pasture grasses. On richer lands it grows to a height of one to two

feet and is often cut for hay. While not a true clover, it is a closely related legume and its roots support a great number of the nitrogen-fixing bacteria,



Burr Clover (*Medicago maculata*)

—This is another legume that comes up spontaneously in some parts of the South. It is an annual which germinates in the fall, growing slowly throughout the winter and maturing early in the spring. It thus affords pasturage at a time when the ordinary grasses are dormant. It grows

well on closely grazed Bermuda sod; this combination will give good grazing every month of the year.

The germ causing tubercles on the roots of this plant does not occur in all Southern soils; but if the rough, uncleaned seed is used, no other soil inoculation will be necessary, since in gathering the seed the curious twisted pods are raked up off the ground and the dust that adheres to them usually carries a sufficient number of these germs to serve for inoculating the field.

This plant is closely related to alfalfa and supports the same root-tuberle germ. When it is desired to sow alfalfa in the Southern states, it is wise to select land upon which the burr clover grows or else to first plant the land to burr clover, using the uncleaned seed.

Alfalfa (*Medicago sativa*). — This mainstay of the agriculture of the West is seldom planted at the South and only seems to succeed in certain restricted localities. Where it can be grown it should be more widely planted as it is a most valuable plant for hay and pasturage. It is a perennial and when once established lasts for a number of years.

Lands should be very thoroughly prepared for sowing alfalfa as it is often rather difficult to secure a stand. One of the chief reasons of failure with this crop at the South is the fact that most Southern soils do not contain the alfalfa tubercle germ, so that soil inoculation in some form is necessary. As has been stated, one of the easiest methods for doing this is to first plant the land to burr clover,

using the uncleaned seed. Alfalfa is an efficient nitrogen gatherer, and old fields of it when plowed are

noted for their richness and productiveness. The plant, however, being a perennial and rather difficult to establish, is usually planted for hay and pasturage rather than for soil-improving purposes.

The seed resembles that of clover and it is sown broadcast and lightly harrowed in.

Peanuts (*Arachis hypogaea*).—In certain parts of the South the peanut is cultivated as a commercial crop; in this connection, however, it will be considered chiefly as a forage plant.

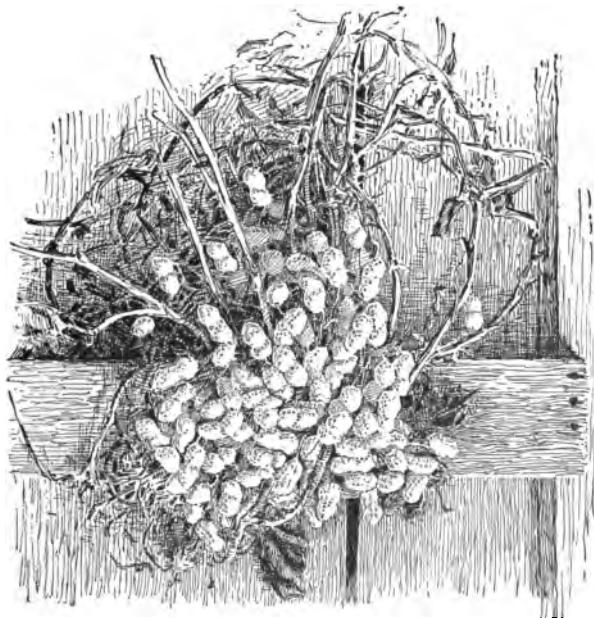
In those regions where the cornfields are utilized for hog pasturage in the fall, it is a common practice to plant a row of peanuts between the corn rows, in-

stead of cowpeas. The peanut, being also a legume, is quite efficient as a nitrogen gatherer. The succulent tops make excellent pasturage for animals of all kinds, and the nuts, which the hogs dig for them-



Alfalfa.

selves, are one of the best known feeds for growing pigs. Older hogs will also fatten on them rapidly, and although the meat is very sweet and fine in flavor it shrinks somewhat in cooking, and the lard is soft and oily ; it is, therefore, best to finish off peanut-fed pigs with a few weeks on corn. The peanut



Peanut.

usually grown for commercial purpose has a trailing, prostrate growth, but the small Spanish peanut grows erect and the tops are much more available for forage, as it can even be cut for hay ; the nuts, too, fill better on average soils than the larger running kinds and, everything considered, it is the most

satisfactory variety to be planted for forage purposes. It grows well on any land suitable for corn or cotton.

Crimson clover, vetch, cowpeas, velvet beans, and beggar weed have been already discussed under the head of green manures. They also constitute the most important of all Southern forage crops. The cowpea is at present much more widely planted and utilized as a forage than any of the others. Where it thrives, it is unequalled; but on light, sandy soils, when it is attacked by wilt and nematodes, it becomes necessary to substitute either beggar weed or velvet beans. The combination of cowpeas and corn in summer, followed by vetch in winter, has already been mentioned as a rapid means of improving the soil. For the stockman and general farmer it has the added advantage of furnishing a maximum amount of the most nutritious forage. It is a combination that is most heartily recommended for all parts of the cotton belt.

FIBER PLANTS

There are a large number of fiber plants that could be grown successfully in the Southern states and the American tropics. Only two, however, are now planted widely enough to require special treatment here. Hemp is locally important in certain regions in Kentucky, and there are some others such as ramie and Sansevieria that are grown occasionally in a small experimental way.

Ramie culture would quickly become an important industry if a successful decorticating machine should be invented. Many attempts in this direction have been made, but so far without success. The plant

grows readily on any strong soil in the Gulf states or the tropics. It is a perennial and yields several cuttings of stalks during the season. The fiber is a



Ramie.

very beautiful one, making a fabric midway between silk and linen in quality.

Immense quantities of jute and other cheap fibers are imported for making bagging. Some of the tropical malvaceous weeds yield a fiber that would be very suitable for this purpose, and there seems no reason why an important industry should not be built up in growing these on a large scale and preparing the fiber for the market.

Cotton (*Gossypium* sp.)

For a large part of the region which this book is intended to cover, cotton is the one preëminently important commercial crop. Its preëminence, in fact, has long been so great as to be a misfortune, for it has been planted so exclusively as to prevent the production of home-grown food supplies and to make a carefully thought out crop rotation impossible. Theoretically, cotton should not be an exhaustive crop to the soil, especially where the seed or cotton-seed meal is returned as a fertilizer. It requires, however, clean cultivation throughout the summer, and the average cotton field is left bare and unprotected from the washing and leaching of the heavy winter rainfall of the cotton belt. The existing system of planting cotton after cotton, year after year, can only end in impoverishing the richest and deepest soils. On the thin, hillside lands so characteristic of large areas in the cotton states, this impoverishment comes very quickly. Countless thousands of acres of these hill lands have been cleared, cultivated to cotton for a few years, until worn and gullied, and then have been abandoned. These abandoned gullied fields give the whole region a most desolate and uninviting appearance to the passing traveler, and this fact has doubtless done much to prevent Northern immigration and to retard the agricultural development of this region, which really presents so many magnificent agricultural possibilities. Thanks largely to the persistent efforts of the Southern experiment stations, the possibilities of mixed husbandry and of better agricultural methods are becoming somewhat widely

A Cotton Field in Fruit.





appreciated, and the next few decades will doubtless witness a complete revolution in the farming methods of the South. This does not mean that cotton will not continue to be the chief export money crop, or that the Southern states will lose their proud position as the foremost cotton-producing region of the world. When each Southern farm shall be so managed that all the grain, pork, fruits, and vegetables consumed on the place are grown at home, and when enough cattle and hogs are bred to consume all the forage that it is possible to produce in a properly planned rotation, only about a third of the area will be planted each year in cotton. The resulting reduction in acreage will be more than compensated for by the much greater fertility of the soil, and the total yield will be greater, not less, than it is at present. That this is no idle theory has been proved many times over by the experience in recent years of those progressive planters who have been the first to adopt the teachings of modern agriculture.

Ever since the days of the Civil War, when the price of cotton was so abnormally high, persistent efforts have been made by England and other European manufacturing countries to encourage the planting of cotton in other countries. So far, however, no other region has been found which can really compete with the southern part of the United States. Considerable quantities of cotton are grown in Egypt and India, and a very small quantity is now being produced in the British West Indies. Attempts are also being made in various parts of Africa. At the time of the Civil War and again in recent years plantings

have been made in Cuba, but never with any permanent success. It seems that in the future, as in the past, the bulk of the world's supply will continue to come from the great Southern cotton belt.

Climate and Soil.—Cotton is preëminently a plant of warm climates. It grows slowly and feebly as long as the nights are cool in the spring and only attains its most rapid growth when the thermometer reaches 90°, or above, at midday, and does not fall below 70° at night. It roots very deeply and hence it can endure drought well, especially if given good surface cultivation. Excessive rains are always injurious, and especially so late in the season when the bolls begin to open. In the cotton states April and May are quite warm and are usually comparatively dry. Abundant showers, as a rule, occur during midsummer, and dry weather is expected in the fall. This makes ideal weather for the cotton crop. When, however, cold rains continue late in the spring, or when, as sometimes happens, the fall is wet, the crop is likely to be seriously injured.

Cotton will grow well on a great variety of soils, but there must be good drainage, as standing water about the roots is quickly fatal to it. On very rich river-bottom soils there is a tendency to grow large stalks at the expense of fruit. The ideal cotton soil is a rich sandy loam; heavy, stiff clay is not desirable, though clay loams give very good results.

Fertilizers.—Commercial fertilizers are now used extensively for cotton on all old, thin uplands. Complete fertilizers are usually employed, but the exact formula varies somewhat widely in different localities.

In fact the cotton grower must be his own judge as to the fertilizer requirements of his soil. If the plants grow tall and rank, and do not fruit sufficiently, use less nitrogen and more phosphoric acid; if on the other hand the stalk is short and feeble, though attempting to fruit heavily, more nitrogen is needed; if the leaves spot and fall prematurely, use more potash. Potash and nitrogen both tend to prolong the active growing season, while phosphoric acid tends to shorten it and to promote the early maturity of the crop. The character of the fertilizer required will depend, too, very largely upon the kind of farming that is being done. If cotton is grown after cotton, year after year, with no change or rotation, it will soon become necessary to add heavier and heavier doses of expensive nitrogen; while if mixed farming is followed with a rotation that includes cowpeas, as often as every other year, it will be necessary to purchase little or no nitrogen, though phosphoric acid and potash may still be needed in small quantities.

Methods of Planting and Cultivating. — Cotton is almost universally planted on raised beds or ridges. On the lighter soils, where cotton follows cotton, no fresh breaking is done in advance of planting. In the early spring a furrow is run between the old cotton rows with a single-shovel plow, fertilizer is deposited in the bottom of this furrow, the workman usually dropping it through a large tin horn, to prevent the wind from scattering it; it is now covered by throwing in a furrow from each side with a turning plow, thus forming the bed, or ridge, in the space occupied by the water furrow the year before. In

the hill lands, where the cotton rows are so generally made to follow the contour lines, the following of the old rows is always strictly adhered to, since it requires a considerable amount of time and trouble to properly lay off the rows in a new field. When planting time arrives, which is somewhere from the first to the last of April, according to the latitude, the beds are freshened up by passing a plank drag or some similar device over them, and a one-horse planter is driven along the top of the ridge, planting the seed in a continuous row, or drill. When the young plants are about three inches high, the first cultivation is given. In the hills, where the contour-line system is followed, the implement used for cultivating is almost universally the heel sweep (see page 34). This is held at such an angle that one wing of the sweep scrapes the surface of the ridge, upon which the cotton is growing. It is usually run about an inch below the surface, and throws a little dirt toward the plant, thus leaving a beneficial dust mulch; and it is very effective in killing young grass and weeds. An expert plowman will run one of these implements so that the end of the sweep will almost touch the plant, thus obviating the use of the hoe. It, however, works only one side of the row, requiring two trips to each row. On level land, where the rows can be laid straight, a regular two-horse corn cultivator can be used to great advantage in the cotton field, for as they work both sides of the row only one trip is required. On level lands, too, disk cultivators can be very economically used for throwing up the beds on which to plant. After the first cultivation, when the plants

are four to six inches high, they are chopped to a stand with the hoe, usually from one to three stalks being left to a hill. The distance between the hills varies considerably according to the richness of the land. On poor, thin lands they are usually left about a foot apart, and on very rich land they are often as much as three feet apart. Cotton should be given clean cultivation during the entire growing season. A cultivator or sweep should be passed through the rows often enough to keep down all weeds and grass, and to break the crust and leave a dust mulch after every rain. It may be necessary to go through the fields two or three times with a hoe, but if the cultivation has been properly done, there will be but little work left for the hoes.

Harvesting. — Cotton picking usually begins early in August, and lasts through November or even later. This work has all to be done by hand and is the most laborious and expensive part of the cotton business. Many attempts have been made to construct mechanical cotton pickers, but so far none of them have been successful. It is the question of picking that limits the possible production of cotton in any given region. When the cotton is picked, it is hauled direct to the gin or to some temporary storehouse. After ginning to remove the seeds the lint is packed in bales weighing four hundred or five hundred pounds. It is pressed very closely in these bales, but when being prepared for distant shipment, the bales are further subjected to heavy hydraulic pressure which reduces them to about a fourth their former bulk.

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Cotton is mostly sold by the farmers to local buyers; each town of any size in the cotton belt being a cotton market.

Uses.—Cotton is, of course, grown for the lint or fiber which surrounds the seeds. This fiber is more universally useful than any other. Formerly no other part of the plant was utilized, the seed being allowed to go to waste at the gins. Now the manufacture of oil from the seed has become a very important business and the sale of the seeds adds an item of much profit to the crop. The cake left after pressing the oil from the seed is ground into a meal which furnishes a rich food for cattle and is also extensively used as a fertilizer.

Its high feeding and manurial value is due to the large percentage of nitrogen which it contains. A good grade of meal will analyze about seven per cent nitrogen. As a feed it is used exclusively for cattle. Horses do not relish it, and it is unsafe to feed it to hogs. Fed in small rations of from one to three pounds per day, in connection with pastureage, corn stover, or other coarse forage, it forms an excellent maintenance ration for work cattle and young steers. To fattening steers, it may be fed in much larger quantities, but if this heavy feeding is continued for more than three months, injurious results are likely to follow. When used judiciously, it is a most useful food for milch cows. It stimulates the flow of milk and, what is an important quality for Southern butter makers, it gives a butter fat with a markedly higher melting point than that produced by other feeds. Heavy feeding with cotton-

seed meal is thought to injure the flavor of the butter, but with moderate feeding no such result is noticed, the only effect being to make the butter stand up and handle better in the warm Southern climate.

Cotton-seed oil is applied to many uses. Combined with tallow it is largely used in adulterating lard; it may also be used in the pure state as a substitute for lard in cooking, and much of it when refined is converted into salad oil.

Botanical Features: Varieties. — The many kinds of cotton grown in the United States may all be grouped under two species: the upland cottons all belonging to *Gossypium hirsutum*, and the Sea Island cotton to *Gossypium Barbadense*.

The seeds of the upland cotton are densely clothed, underneath the fiber, with a coating of short greenish hairs, and the flowers are white or light cream color when they first open, turning pinkish as they wither.

The Sea Island cotton has smooth, black seeds and the freshly opened flowers are bright yellow.

The perennial, so-called tree cotton of tropical America belongs to a species closely related to the Sea Island cotton. It is frequently seen planted about dwellings, but is of no commercial importance.

There are many varieties of upland cotton in cultivation. These can be placed in two principal groups: the cluster cottons and the long-limbed, big-bolled cottons. Varieties of the first class are usually earlier in maturing and are the only ones planted in the more northerly part of the cotton belt. The big-bolled cottons do best, as a rule, on the moister, richer lands.

The upland cottons are quite plastic and variable, so that improved strains are readily secured by attention to seed selection. Some of these better strains now almost equal the Sea Island cotton in length of fiber, and command a considerable premium over the common grades in the market. Sea Island cotton is much less extensively cultivated, and but few named varieties have been developed. It has been found possible, however, to greatly improve it by seed selection, and many of the more prominent planters have special strains of their own growing. The phenomenal success obtained by experts from the Department of Agriculture in selecting a strain of Sea Island cotton that is resistant to the terrible wilt disease is one of the most striking examples of the wonderful possibilities that may be secured by care in selecting the seed of our cultivated crops.

Diseases and Insects. — The insects attacking cotton have been very thoroughly studied by the entomologists of the United States Department of Agriculture, and are fully discussed in their various publications. The three most important are the boll weevil, the boll worm, and the caterpillar. Of these the boll weevil is by far the most destructive, and threatens seriously to curtail production. This insect is a native of Mexico, Central America, and Cuba. It finally crossed the Rio Grande into Texas, and for a number of years has been spreading steadily northward and eastward, until it now seems certain that it will eventually occupy the entire cotton belt of the Southern states. So far

it has not been found in Jamaica, Porto Rico, or the smaller West Indies. The female beetle deposits her eggs in the soft young bolls or in the flower buds; the young grub developing within the tissues of the plant is protected from the application of insecticides, and no practicable remedy has been found for destroying this terrible pest. The insect passes the winter in its adult stage and within the boundaries of the United States comparatively few of them are able to persist until the season for the flowering of cotton. The first brood, therefore, does little damage; they multiply rapidly, however, so that in all infested regions the later, so-called top crop is almost completely destroyed. By taking advantage of these facts, cultural methods have been devised by means of which it is still possible to produce a fair crop, notwithstanding the presence of the weevil. The earliest maturing varieties are selected, seed is planted as early as possible, and fertilizers are applied and cultivation given with the view of hastening the ripening of the crop in every possible way. After the first pickings have been secured, or as soon as the majority of the young bolls are seen to be infested, the entire crop is promptly plowed under, without attempting to harvest the later pickings. Great pains should be taken to destroy absolutely every cotton plant in order to prevent the maturing of the late brood of beetles. Profitable crops are now being secured in even the worst infested regions, although the yields obtained are necessarily smaller than when it was possible to continue picking throughout the season. Success with

these new methods requires the selection of the earliest possible strains of cotton, and of those which tend to heavy flowering early in the season. The use of a large percentage of phosphoric acid in the fertilizer employed is also important, since this substance tends to promote heavy fruiting and early ripening. Heavy applications of nitrogen and potash, on the contrary, have a tendency to prolong the growing season and to retard the setting of the crop. Experiments in Cuba have shown that even under tropical conditions it may be possible to grow cotton in spite of the presence of the boll weevil, by treating it strictly as an annual crop, and promptly destroying the plants at the end of the picking season, provided that the precaution is always taken of destroying all of the half-wild native cotton throughout a considerable surrounding area.

The boll worm is closely related to the cutworms. The young larvæ bore into the bolls, and, after feeding for a time, emerge and enter fresh bolls, the same larva thus destroying several bolls in a few weeks. Besides cotton, these insects bore into green tomatoes in the same manner, being a very destructive enemy of this crop in all parts of the South. The boll worm is also the familiar corn worm so frequently found entering the ends of the ears of green corn. While these three are its usual food plants, it is not confined to them, as it is occasionally found boring into various other fruits and pods. Owing to its habit of feeding so largely on the interior tissue, this insect is very difficult to combat by the use of insecticides ; in fact, no effective remedy has

been devised for it. The losses that it occasions reach large figures each season. It has been found to slightly prefer corn to cotton, and a small measure of protection may be secured by planting occasional rows of corn through the cotton field. During the period when the corn is in silk, the worms will be attracted by it instead of by the cotton.

The cotton caterpillar is also related to the cut-worms and the army worm. In habit it is much like the latter. In certain seasons it suddenly appears in immense numbers, and if allowed to go unchecked, will, in a very few days, entirely defoliate even the largest cotton fields. When this insect first appeared, it created great alarm, and for some years caused enormous losses to the cotton industry. However, it was soon found to be easily controlled by the use of Paris green, so now the loss from it is small. The Paris green is usually applied in the form of powder. A quantity is placed in each of two thin muslin bags, which are tied on the ends of a short pole, that is the length of the distance between the rows of cotton ; this pole is then placed across the saddle in front of a man on a mule, who rides up and down between the rows, the jolting of the mule sifting enough of the Paris green through the muslin to poison the leaves effectively and economically. It is only in occasional years that this insect appears in sufficient numbers to attract attention. A serious outbreak can be quickly subdued by the above simple remedy.

The diseases of cotton were first seriously studied by Professor G. F. Atkinson, while connected with the

Alabama Experiment Station. The literature of the subject will be found in the bulletins of that institution and in the publications on plant pathology issued by the Department of Agriculture.

Only the more important of them will be considered here.

The term "rust" or "blight" is applied to a widely occurring diseased condition of cotton, the most conspicuous feature of which is the spotting and premature falling of the leaves. These spotted leaves are found to be infested by any of three or four different species of fungi. These are all, however, what are known as facultative parasites; that is, they are only able to invade leaves that have been weakened by some other cause, and cannot, like the true rusts, attack them when growing vigorously. The disease is an obscure one and its exact nature has not yet been satisfactorily determined. It is usually worse on thin, sandy lands, and is especially serious when periods of excessive rainfall are followed by a sharp drought. It may, however, be induced by any unfavorable conditions that suddenly arrest growth. The facts seem to be that while leaves are young and thrifty they have the power of repelling the attacks of these fungi, but as they approach maturity or have their vitality suddenly checked they are no longer able to do so. With the development of the fungi the leaves soon turn yellow and fall off, thus preventing the maturity of all the later part of the crop. In badly rusted fields the yield will be reduced to a half or a fourth of the normal. That this disease is primarily connected with the nutrition of

the plant is shown by the fact that richer places in the field, as for instance old fence rows, always show a considerable immunity, and further that the disease can be quite effectively controlled by incorporating more vegetable matter in the soil and by applying potash. On many soils the application of from a hundred to two hundred pounds of kainit per acre will act almost as a specific. The excessive use of phosphoric acid without potash greatly increases the injury. On land subject to rust the disease can be quite perfectly controlled by following a rotation like that suggested on page 145, which shall provide for at least one crop of cowpeas between cotton crops, and by the use of fertilizers rich in potash. In other words, the appearance of rust is a sure indication of soil exhaustion.

Cotton wilt (*Neocosmospora*) or Frenching, as it is sometimes called, is due to the growth of a fungus within the tissues of the stem and roots. Affected plants soon become somewhat dwarfed and the leaves assume an unnatural aspect, sometimes being streaked with yellow or brown. Usually after a time the whole plant suddenly wilts and in a few days dies. When only a part of the stalk is affected, the plant may linger throughout the season and even produce a partial crop. The fungus develops principally along the ducts in the vascular bundles, where its presence can be detected by the brown staining of the bundles, which is easily seen when cutting off the diseased stem. The sudden wilting occurs when the fungus develops so rapidly as to plug these ducts and thus prevent the upward flow of sap from the roots. This fungus is able to live over in the soil from one season

to the next and when it once makes its appearance in the field, the diseased area continues to spread from year to year until finally the culture of cotton has to be abandoned.

The disease occurs in many parts of the cotton belt, but has been most destructive in the famous Sea Island cotton region along the coast of Georgia and South Carolina. At one time it seriously threatened to prevent the culture of this crop on many of the lands best suited to it. Officials of the Department of Agriculture were detailed to study the disease, and they observed occasional plants in the infected areas that remained healthy and vigorous throughout the season. Seed was saved from these plants and in the course of a few years a resistant race was developed, by selection, which possessed almost complete immunity from this disease. Strains of resistant upland cotton have also been found, so that it is now possible to grow full crops of cotton on lands that are thoroughly infested by the wilt fungus. This is one of the most striking instances of the possibility of overcoming a serious plant disease by the selection and breeding of immune races. Fungi that are microscopically indistinguishable from the one causing cotton wilt produce similar diseases in cowpeas, watermelons, and various other crops. It seems to be a fact, however, that the disease is not usually communicable from one of these crops to another. No methods have been discovered for treating these wilts by topical applications.

Another disease known as root rot (*Ozonium*) causes the wilting of cotton in certain portions of Texas. It

is caused by a fungus which attacks the outside of the roots, enveloping them in a web of yellowish fibers. The same fungus attacks a large number of other plants; no effective remedy has yet been found and cultivation of cotton has been practically abandoned on infected areas.¹

A disease known as anthracnose (*Colletotrichum*) is common in nearly all parts of the cotton belt. This fungus causes small sunken spots, usually surrounded by a reddish brown border. It often appears on the young seed leaves, when they first emerge from the ground; it also develops on the stem, and is found with other fungi on the leaves of plants affected with rust, but the principal injury it causes is to the bolls. If the young bolls are badly affected, they fail to open properly, but often crack prematurely, thus causing the rotting of the immature contents. The disease is usually worse on rich lands and in wet seasons, which cause a rank, sappy growth. No practical remedy is known.

Cotton bolls are also often destroyed by a bacterial disease known as boll rot. Like the anthracnose this is worse in wet seasons, and on rich, moist lands. This disease has not been fully studied, but is probably conveyed from boll to boll by the puncture of insects. The only remedial measure is to plant at sufficient distance to allow for a free circulation of

¹ While the above lines were in press a paper has appeared (U. S. Dept. Agric., Bureau of Pl. Ind., Bull. 102: 39-42) on "The Control of Texas Root-Rot of Cotton," by Shear & Mills. As the result of recent experiments the authors advise very deep fall plowing of infected lands and also a strict rotation with grass or grain crops.

air, thus securing the prompt drying of the bolls, when wet from rain or dew.

Another serious trouble of the cotton planter is the shedding of the young bolls, thus causing the plant to fail to set a sufficient crop. This shedding is not due to insects or fungi, but seems to be caused by some derangement of nutrition. It may occur if the weather is either too wet or too dry; but is more frequently caused by a period of sharp drought following abundant rains that have caused the plants to take on a rapid growth. No remedy is known except to give such cultivation as will avoid, so far as is possible, sudden checks in the development of the plants.

Sisal (*Agave sps.*)

This plant furnishes a strong, coarse fiber that is largely used in the manufacture of rope, binder twine, and other cordage. For these purposes it is excelled in importance only by the Manila hemp, which is produced by a species of banana, grown in the Philippine Islands. Sisal, or heniquen, as it is often called, is grown very extensively on the Yucatan peninsula in Mexico, and is also planted to some extent in the Bahamas and at certain points in northern Cuba. To succeed best, the plant requires a dry, rocky, limestone soil. It does not withstand frost, so can be grown only in tropical regions. While the plant grows well on deeper, richer land, it is too pulpy in such situations and yields a smaller percentage of fiber. Commercial plantings are entirely confined to



Sisal.





regions where the soil is too thin and rocky to produce other crops. No fertilizers are used for sisal. The plants when growing thriftily throw up numerous suckers from the roots. These are used for starting new plantations. Bulbels are also produced in immense numbers on the flowering stalks. These are sometimes used for planting, but require from one to two years longer to reach maturity. The ground selected for sisal is usually too rocky to admit of plowing, and is, therefore, cleared of brush with a machete, and the dry grass and brush is burned. Small holes are now chopped in the soil at a distance of from seven to nine feet and a sucker planted in each hole. No great pains is required in planting, except to see that enough earth or stone is piled around the sucker to hold it erect. Subsequent cultivation consists simply in chopping down grass and weeds with hoe or machete as often as may be necessary to prevent them from smothering the plants. From three to five years are required before the plants gain sufficient size to admit of harvesting. After this time one or two of the large, fleshy, lower leaves may be cut each month, and as the plant continues to yield for a number of years, the total amount of fiber produced is considerable. With the price that has prevailed since the Spanish-American War this industry has been very profitable. The leaves are taken to a pulping machine which separates the fiber. This is dried and then baled for market.

The kind usually found in the Bahamas differs somewhat from that of Yucatan and is considered to

be a distinct species. They are about equal as fiber producers, but the Yucatan variety lasts longer before flowering, so that fields do not require replanting as often. These plants, like all the other Agaves, or so-called century plants, produce only a rosette of stiff, fleshy leaves for a number of years, the number differing with the species, when a gigantic flower stalk appears, and after flowering the plant dies. Other fiber-yielding species of the same group occur in Mexico, also in Cuba, and other of the West Indies, but none have so far proved of much commercial importance.

But little attention has been paid to the diseases and insects of sisal. Plants are sometimes infested by mealy bugs, and they are also attacked by a fungus which causes an anthracnose, or pitlike spotting of the leaves; no remedies are used for either trouble.

TOBACCO (*Nicotiana Tabacum*)

Tobacco is a plant of great importance to Southern agriculture. While grown under a rather wide range of conditions, its cultivation is usually restricted to certain well-defined areas, where the farmers have become accustomed to the methods of handling this exacting and sensitive crop.

The different classes of tobacco have different requirements as to soil and climate. The heavy plug tobaccoes require a rich, rather heavy clay loam ; while to produce the best types of cigar tobacco, a light, sandy soil is necessary. Bright plug and smoking

tobaccos, being intermediate in quality, require intermediate grades of soil ; but in every case the soil must be in the best possible state of tilth, and if not abundantly supplied with all the elements of fertility, these must be freely added in the form of fertilizers and manures. Tobacco soils should contain much humus. The crop is a very exhausting one, and even the richest soils soon become depleted of this important substance, unless active measures are taken to maintain fertility. This can be done by the free use of stable manure supplemented by the addition of some form of phosphoric acid and of potash. This latter substance is especially necessary in the cultivation of cigar and smoking tobaccos, since the burning quality as well as the flavor, or aroma, is largely dependent upon its presence. Tobacco draws very heavily upon the supply of potash in the soil, and it is of great importance to guard carefully against its exhaustion.

In the application of potash to tobacco land special care must be taken to exclude all forms of this material that contain chlorine, as this substance, when present, even in small quantities, spoils the burning quality. The muriate of potash and crude salts, like kainite, should, therefore, never be used. The high-grade sulphate is the form in which potash is most often applied to tobacco, but the carbonate, though slightly more expensive, is preferred by some when the highest type of cigar tobacco is desired. Stable manure, although so useful, is usually unduly expensive in Southern countries, even when it can be obtained at all. The long growing season at the

South, however, usually will permit of the growing of some leguminous crop while the land is not occupied by the tobacco, and when this can be done, it can safely be substituted for the more expensive stable manure. This is especially true in Cuba and Porto Rico, where tobacco is a winter crop and the land lies idle throughout the rainy summer season. When the tobacco growers of these regions shall all have learned to plant their harvested tobacco fields in the spring to velvet beans, the rank growth of these vines during the summer will furnish an immense amount of nitrogenous vegetable matter to be plowed under in the fall, and the results will be a great economy over the methods of manuring now in vogue. Tobacco only requires a short growing season, and therefore thrives under a great variety of climatic conditions. It requires less water than many other crops. Frequent showers are an advantage during the early period of growth, but dry weather is to be preferred as the plants approach maturity and during the time of harvesting and curing. Where water is available for irrigation, the dry winter months of Cuba and Porto Rico furnish ideal weather conditions for its growth.

The best formula for tobacco fertilizers will naturally differ with different soil conditions, but one containing two parts of phosphoric acid and two parts potash for each part of nitrogen will be well adapted to average conditions.

Planting and Cultivation.—Tobacco is always sown in seed beds, and the young plants are transplanted to the field when of sufficient size. Seed-bed problems

are among the most important for the tobacco grower, this being especially true in tropical countries. The primitive method of making seed beds, and one that is still very largely in use, is to clear a space in the forest, burn the brush where it lies, and after slightly stirring the soil with a hoe to incorporate the coating of ashes, the seed is scattered broadcast. At the North a low frame is usually built around the bed and covered with cloth to protect the young plants from cold. The advantages of this method are that strong, fresh soil is secured for the young plants, and all seeds of weeds which might otherwise overshadow the tiny tobacco plants have been destroyed by fire. More important still, however, is the fact that the fire has also served to sterilize the soil by killing the mycelium of the various damping-off fungi, by which it is so often infested. This is a matter of the utmost importance at the South, where seed beds are started during warm weather. When damp, rainy weather follows the sowing of seed beds in Cuba and Porto Rico, immense losses are occasioned by the damping off of the young plantlets. The trouble is not so serious at the North, where seed is sown in the cool weather of the spring; but whenever it is found necessary to make seed beds on old land, some method for sterilizing the soil should be adopted. This may be accomplished by piling on brush and burning it, the same as in the woods, by applying live steam through perforated pipes, or by the free use of boiling water. Chemical sterilization is also practicable. Thoroughly spraying the surface of the soil, both before and after sowing, with Bordeaux mixture, gives a considerable

protection from this trouble. Applications of formalin to the soil before sowing also prove effective, but the expense is too great to make it a feasible remedy. Soils are now quite widely sterilized for greenhouse purposes by the use of live steam, and where steam boilers are at hand this is probably the most efficient system of soil sterilization.

When the young plants are from four to six inches high, they are ready to move to the field. The ground should have been plowed, cross plowed, and thoroughly harrowed in order to put it in the most perfect condition of tilth possible. Light furrows are now opened for the rows, and if commercial fertilizer is used, a portion at least is scattered in the furrows. The distance between the rows will depend upon the type of tobacco to be grown. For cigar tobacco three feet or even less is usual; but the heavier kinds require a greater distance. The young plants are now planted by hand or with a dibble in the bottom of these furrows, the cigar types being one foot or less apart and double the distance for the heavier ones. Mechanical planters drawn by horses are also in use in some sections. Young tobacco plants, if pulled from the seed beds in proper condition, are very resistant, and if the soil is at all moist they will not require watering when transplanted; but in very dry weather watering is essential. Plants are likely to wilt badly at first, but in two or three days, when new rootlets have been formed, will stand erect and soon begin to grow rapidly. As soon as this wilting is past, the first cultivation should be given, in order to fill in the planting furrow. From this time

on cultivation should be frequent until such time as the plants get large enough to practically shade the ground. In Cuba this cultivation is all done with the hoe, but this is unduly expensive. Any of the one-horse cultivators with numerous small teeth can be used successfully in young tobacco. As the plants get older a heel sweep, so much used by the cotton planters, is preferable, as the long, narrow wing will stir the ground under the leaves without breaking them. When the tobacco reaches a certain height, depending upon the kind and the richness of the soil, it is topped by pinching out the terminal bud in order to prevent its seeding and to give an increased development to the leaves. Suckers will now start in the axils of the leaves, and it is necessary to go over the field every few days to remove them, thus confining the growth to the leaves already formed on the stem.

It has been found that growing the plants in partial shade profoundly affects the character of the leaf, making it thinner and also freer from gum resins and nicotine. The plants, too, grow taller and the leaves are larger, making them more useful for cigar wrappers. In Cuba rows of bananas are often planted in the tobacco fields to furnish shade and act as wind-breaks. The practice of covering tobacco fields with cheese cloth to give shade and thus secure leaves of greater value for wrappers originated in Connecticut, but is now more employed in Cuba and Porto Rico. The cloth, which is specially woven for the purpose with strong threads and wide meshes, is stretched over wires that are supported by posts high

enough to admit of horse cultivation. The sides as well as the top are covered, thus giving protection from winds and incidentally excluding insects. Notwithstanding the expense involved, this method often proves highly profitable, owing to the high prices obtained for superior wrappers; but there is always danger, especially on light soils and in cloudy weather, that the shading may be overdone, in which case the leaf will be too thin and papery and will lack the elasticity necessary for a good wrapper. Shade-grown tobacco never develops the full aroma of that produced in the open air.

Harvesting. — When the leaves are fully grown, one accustomed to tobacco will note a slight change of color, which indicates the approach of maturity. It requires experience and good judgment to know just when to cut tobacco, as the quality of the crop depends to a considerable degree upon the exact stage of ripeness at which it is harvested. Just prior to the change of color, before alluded to, the glandular hairs which cover the surface of the leaves are very active in secreting an essential oil that accumulates in little globules at their tips. Later this dries to a small resinous mass, so that tobacco which has become too ripe is less aromatic, stiffer, and more brittle upon curing.

Three different methods of cutting tobacco are employed. In some places the entire plant is cut at the ground, carried in, and hung on poles or laths in the curing barns. In Cuba the usual custom is to cut the stem into short pieces in such a way that two leaves are left on each piece; these are then hung on

the poles. With the best grades of high-priced tobacco it is now more usual to harvest the leaves singly and string them for curing by passing a needle through the thick midrib. As the lower leaves always mature first, this plan enables the planter to make two or three cuttings and harvest each leaf in the best condition of ripeness, and thus gives a greater uniformity in the product. Cigar tobaccoes are generally allowed to cure naturally without the use of heat. With some of the plug tobaccoes artificial heat is usually employed in the curing barns. In either case great care and considerable experience is required during the curing process. Tobacco barns are generally so built that they may be either closed tightly or given free ventilation according to the state of the weather and condition of the contents. The curing of tobacco depends upon the action of internal ferments, called enzymes, such as are concerned in the ripening of fruit and in producing the autumn coloration of forest leaves. Drying must not proceed too rapidly or these enzymes do not have time to do their work, and instead of the rich attractive brown the tobacco will turn to a dirty green. That this change of color is due to activities taking place within the living cells of the leaf may be conclusively shown by crushing the cells over certain areas; as when a name is written heavily on the leaf with a pencil, such injured areas remain green upon drying, and the name appears in green letters upon the brown background of the leaf. A rather moist air should be maintained in the tobacco house during the first few days of curing, in order to

allow time for these fermentative changes. Later more ventilation must be given, especially if the weather is damp; otherwise there will be great danger of mold, which will seriously injure the leaf. After the tobacco has become thoroughly dry it is taken down from the poles and tied in small bundles called hands. A damp day is selected for this work, so that it can be done without breaking the leaves. These hands are banked together in a pile and are carefully covered to induce a further fermentation. If not damp enough, it is slightly sprinkled. The temperature of the pile is carefully watched, and before it gets hot enough to cause injury the pile is torn down and rebuilt in such a way that the hands which were on the outside are now placed in the center. The extent to which the fermentation is carried depends upon the character of the tobacco, and like the cutting and curing, requires careful and experienced oversight. After the fermentation tobacco is carefully sorted into different grades, when it is ready for bailing and shipping.

Botanical Features. — Botanically, tobacco belongs to the great family of the *Solanaceæ*, which gives us such other well-known economic plants as the potato, tomato, egg plant, and pepper. Tobacco flowers are adapted for self-pollination, and this has an important practical bearing upon the question of seed selection. When a plant of a particularly desirable type appears in a field, if an ordinary paper bag is slipped over the inflorescence just before the first flowers open, it will exclude all foreign pollen, and the seed produced will be the pure progeny of the one desirable plant.

Tobacco comes very true to type, and a single plant yields such a large quantity of seed that it is easy, with a little care, to secure a sufficient supply from the best plants. A considerable number of varieties of tobacco are in cultivation that are adapted to the different purposes for which it is grown; but all of them can easily be much improved by a little care in seed selection.

Diseases and Insects. — Tobacco is attacked by a number of diseases and insects, only a few of which can be discussed. The damping-off fungus (*Rhizoctonia*) that causes such heavy losses in the seed beds, especially in the tropics, has already been referred to, and several methods of combating it suggested. This must be considered as one of the most serious diseases of the crop, and much more study is needed to determine the best way of controlling it under different conditions. The flea-beetle (*Epetrix*) is also quite frequently injurious in the seed beds, biting small holes on the under side of the leaves. This insect is repelled to a considerable extent by applications of Bordeaux mixture. Spraying the young plantlets with Bordeaux as a preventive for the damping-off fungus will also serve to largely obviate trouble from this pest. For the flea-beetle it is best, however, to add Paris green to the spray. It is probable that applications of Bordeaux mixture to tobacco seed beds will always more than pay their cost in the increased vigor of the plants secured, even when no serious outbreak of damping off occurs. When the plants are set in the field, they are liable to be destroyed by various cutworms and other related

larvæ. Baiting the field in advance of planting with a poisoned bran mash is the best remedy for these insects. It is best to sweeten the mash with a little molasses, which will also make it more adhesive. It should be scattered in the field at least a week before planting.

The well-known large green tobacco worm, which is the larva of a Sphinx moth (*Protoparce*), is a widely destructive tobacco enemy. It may be controlled either by hand picking or by dusting with Paris green. In the tropics Paris green is also largely used for insects of the climbing cutworm type.

Several fungous leaf-spot diseases of tobacco are known, but as a rule they are not seriously troublesome, and little attempt has been made to treat them. Bordeaux mixture would be the natural remedy, but its use is not permissible as it adheres so long that its presence on the leaf would be objectionable. Bacterial root rot of tobacco has appeared in certain localities, but so far it has been rather local and as yet no efficient remedy can be suggested.

An obscure disease of tobacco that is not of parasitic origin occurs quite frequently and is widely distributed. The plant becomes somewhat dwarfed, the leaves are wrinkled, and streaked and spotted with yellow; it is known under various names, but the term "mosaic disease" is the one usually applied, on account of the peculiar coloring of the leaves. The disease seems to be entirely functional and is due to the improper secretion of some enzyme. This trouble seems to be induced by anything which strongly shocks the plant and suddenly interrupts its





Coffee Tree with Fruit.

growth. It can be induced artificially by injuring the roots. When the crop is harvested, the suckers which spring up from the roots often show the disease, even though the parent plant was entirely normal. Plants that have been burned by improper applications of Paris green also often develop mosaic disease. Good cultural methods which avoid shock or injury of any kind to the plant, and which keep it growing steadily and thriftily, are the best safeguards against this trouble. Care in the seed beds is also necessary, since poor, stunted plants are more likely to develop this disease.

COFFEE (*Coffea ssp.*)

Coffee is strictly a tropical product. In a natural state it grows as an undershrub in mountainous forests, and when cultivated the same conditions must be somewhat closely approximated. It is grown extensively in Mexico, Central and South America, and Porto Rico. Formerly it was one of the principal crops of Cuba; but owing to the high price of labor and the greater profit in sugar cane, its cultivation has been nearly abandoned.

The best coffee is usually grown at an altitude of from two to five thousand feet, and often on land too steep for the cultivation of other crops. It is injured by periods of prolonged drought and thrives best where the rainfall is somewhat evenly distributed throughout the year.

The best soils are rather heavy clays well provided with humus.

Coffee is usually planted on forest lands. In some cases the underbrush is simply cut away and the trees are thinned, leaving only enough of the original growth standing to afford the partial shade that is necessary for the plants. At other times the land is entirely cleared and special kinds of shade trees are planted with the coffee. Different trees are preferred in different regions. Leguminous trees are the ones usually selected, since these are always provided with root tubercles and serve to enrich the soil by collecting atmospheric nitrogen in the same way as the soil-improving herbaceous legumes. At the higher altitudes shade is unnecessary and is seldom used.

Young coffee plants are often pulled up for transplanting where seeds have germinated under the trees in an old plantation, but it is better to prepare special seed beds, in order that the seedlings can receive some attention. The seed beds must be shaded; palm thatch usually serves for this purpose. The young trees are planted when about two feet high at distances varying from six to ten feet apart. The mistake is often made of planting too closely. This gives weak, spindling trees which are more subject to various diseases. Horse cultivation is seldom attempted, but the ground between the trees is kept clean with hoe or machete. When the forest is entirely cleared, bananas are often planted in order to make a quick, temporary shade while the permanent shade trees are growing. When this is done, constant care is required to keep them sufficiently thinned out to prevent the crowding and overshading of the coffee, and they should be entirely dug out as soon as

the permanent shade trees have grown large enough to answer their purpose. It is usual to give the trees heavy annual prunings to keep the crop down within easy reach of the pickers.

The ripe coffee berry is a red fruit the size of a small cherry. Harvesting the fruit has to be done by hand, and this constitutes one of the largest items of expense. The berries are passed through a rude pulping mill, after which the seeds are spread on large cemented floors to dry in the sun. After becoming thoroughly dry they are cleaned, graded, and polished, and then are ready to sack for market.

Most of the coffees in cultivation are supposed to belong to a single species.

The Liberian coffee is, however, entirely distinct; the tree grows much larger and stronger, and the fruit and seed are also larger. Like most cultivated plants coffee is quite variable in character, but so far very little attention has been given to the selection of improved strains. Here, as with most other tropical products, a great field is open for the work of the intelligent plant breeder.

Diseases and Insects. — Like all other cultivated crops, coffee is subject to the attacks of various fungi and insects. The only insect enemy that has attracted wide attention is the leaf miner (*Leucoptera*), a minute, lepidopterous larva, which burrows in the leaf tissue, forming large, irregular, deadened areas. It occurs abundantly in all parts of the American tropics, and does very considerable injury by so greatly reducing the active leaf surface. When ready to transform, it emerges and spins a very

delicate cocoon on the under side of the leaves. Experiments at the Cuban Experiment Station have shown that it is possible to kill large numbers of the insects when in this stage by spraying with kerosene emulsion. As the pupal stage lasts but a few days, frequent sprayings are required in order to be effective, and in most cases the expense will probably be found to be too great to make the remedy a practical one.

A large aphid and various scale insects sometimes attack coffee, but they are usually soon controlled by their natural enemies.

The rust fungus (*Hemileia*) that has caused such heavy losses in the East Indies has so far not appeared in the American tropics, but there is a rust-colored leaf spot (*Stilbum*) that occurs quite commonly and which sometimes causes considerable injury. The spots are sometimes confused with those caused by the leaf miner, but the *Stilbum* spots are always circular, not irregular, in outline, and in moist weather close examination will show them to be covered with the minute, short-stalked, orange-colored, fruiting bodies of the fungus. This disease is usually troublesome only when the coffee is overshaded. Thinning out the plants and removing some of the shade is the only remedy required.

In some regions many coffee trees are lost from the attack of a fungous root rot. The disease spreads slowly in concentric circles, from each center of infection. It has not been thoroughly studied, and the only remedy that can be suggested would be to

ditch deeply around each such infected area, thus cutting off the underground spread of the fungus.

CACAO (*Theobroma Cacao*)

The cultivation of this crop is very similar to that of coffee, and, as a rule, it is found in the same general regions, but thrives best at a somewhat lower altitude, most of the plantations being under two thousand feet and some even are almost at sea level. Cacao requires a rather moist climate, with equable distribution of rainfall; the soil should be deep, rich, and well drained. The method of planting is much the same as coffee, but the trees, being of slightly larger growth, require to be planted at a distance of as much as twelve or fifteen feet. In a few cacao-producing regions it is grown without shade, but generally shade trees are provided.

The seeds from which commercial chocolate and cocoa are prepared are produced in large conical or pear-shaped, fleshy pods, which somewhat resemble small musk melons. They grow directly from the trunk and larger branches. When mature, these pods are cut open and the beans placed in tubs or vats to pass through a process of fermentation. After two or three days they are taken out and spread upon cement floors to dry. On the larger estates the beans are often dried by artificial heat with various devices, somewhat similar to those used for drying fruit.

Great care and some experience is necessary in order to conduct the operations of fermenting and

drying properly, as the quality and market price are very easily injured.

A number of well-marked varieties are in cultivation. One known as the Creolla is probably most generally planted; it is a hardy, productive, red-seeded kind that thrives under a wide range of conditions. Some of the more delicate, white-seeded varieties have a finer flavor and command higher prices in the market.

Cacao is subject to a considerable number of rather serious diseases. Thrips often do much damage to the young pods. Two or three different fungi cause serious pod rots, and other fungi cause cankers on the stems that greatly weaken and sometimes kill the trees. There is also a root-rot fungus in some regions and in Surinam the industry has been almost extinguished by the outbreak of a witches'-broom disease.

RUBBER

Rubber is prepared from the milky juice of a number of species of trees and vines. Only two are of much importance in the American tropics. These are the Mexican rubber (*Castilloa elastica*) and the Brazilian rubber (*Hevea Brasiliensis*). So far, the commercial supply of rubber has mostly come from wild forest trees. Wasteful methods of harvesting which have rapidly exhausted the more accessible sources of supply, and the immense increase in the use of rubber in the arts, long since forcibly called attention to the necessity of producing it by agricultural methods. Much money has been expended in making rubber plantations, especially in southern



The Mexican Rubber Tree (*Castilloa elastica*).

Mexico, and many companies of a semispeculative nature have been organized for this purpose. It requires a number of years before rubber trees reach the productive age. A few of the Mexican plantations are now nearing an age when they will begin to produce, so we will soon know more as to the probable outcome of these investments.

Castilloa seems to lend itself more readily to cultural methods than *Hevea* and this is the species that has been most planted. There is no question but that the tree can be grown successfully under a wide range of conditions. More light is needed, however, as to what conditions will prove best adapted to promoting a free flow of latex; and more experience is needed on many other points in regard to the best way of managing rubber plantations. The commercial planting of other species of rubber is proving a success in some of the East Indies.

It is not likely that the roseate promises contained in the prospectuses of the speculative rubber companies will ever be fully realized, but in view of the immense demand and the high prices now prevailing, there is every reason to hope that under conservative management American rubber plantations will prove to be profitable and the business of rubber planting seems destined to be greatly extended in many parts of the American tropics.

FRUITS

Temperate Fruits

The fruit industry has come to be an important one in many parts of the South. The commercial

fruits may be roughly grouped into three classes: those of temperate regions, the subtropical ones, and those which are strictly tropical. The limits of this work will only admit of a brief discussion of those of chief commercial value, taking up first those that belong more especially to the temperate regions.

Peaches (*Persica vulgaris*). — This is easily the most important of the temperate fruits for the region under discussion. Peaches are grown commercially on a large scale in many parts of the South, especially in the Carolinas, Georgia, and Texas. Climatic conditions are sufficiently favorable for at least some of the races of peaches in all parts of the Southern states. High lands should be chosen instead of low, on account of their greater freedom from late spring frosts. These frosts, coming after the blossoms are open, frequently cause heavy losses, and constitute one of the most serious drawbacks to peach cultivation. Peaches will grow in almost any well-drained soil, but very rich land is not advisable, as it causes too rank a growth. The best lands are light, sandy loams that have a larger proportion of clay in the subsoil. Good upland cotton soils are usually good peach lands.

Peach pits are generally planted in the fall, scattered five or six inches apart in about four-foot rows. The young trees will be large enough to bud by the following August. These buds remain dormant during the winter, and in the spring, before growth starts, the stock is cut back to just above the bud, thus forcing all the growth of the tree into the in-

serted bud. Young, well-cared-for peach trees grow rapidly, so they will be ready to move to the field after one season's growth. Strong-growing seedlings are sometimes budded in June. After a few days the tops are lopped to force the bud into immediate growth, and such June buds often make sufficient growth to be planted the following season.

At the South, where there is no hard freezing to heave out the freshly planted trees, planting may be done at any time during late fall, winter, or early spring. The usual distance between trees is about twenty feet each way, although some growers plant them considerably closer. The principal points to secure success in tree planting are, to see that mellow ground is tramped closely about the roots and that the top is heavily pruned to compensate for the roots that are necessarily lost in transplanting. Care should also be taken not to expose the roots to undue drying by sun and wind. The young orchard should receive thorough cultivation during the entire summer. In the cotton belt, the land between the trees may be safely planted to cotton for the first two years, since the culture given to this crop is exactly that required by the young orchard. Corn is also sometimes planted in young orchards, but is a less desirable crop than cotton, as it grows tall enough to shade the small trees and draws more heavily on the soil moisture and fertility. On the advent of fall the land should be sown to rye or winter oats to guard against undue washing by the winter rains. These crops must be plowed under in the spring, however, and by no means be allowed to

mature ; nothing is harder on a young orchard than the making of a crop of small grain, since it prevents the stirring of the ground in the spring at the time when such cultivation is most needed. When lands are not too rich, crimson clover or vetch may be wisely substituted for rye as a winter cover crop ; but these legumes add so much nitrogen to the soil that their continued use is not always advisable in a peach orchard.

Peaches require more pruning than most other fruit trees. The orchard should be gone over systematically every winter, shortening in and thinning out the limbs. During the long growing season at the South peaches grow so rapidly that it is best to go over the orchard two or three times in the summer to pinch back the ends of the rapidly growing shoots; this will promote branching and by a little care a symmetrical top can be formed. If no summer pinching is done, the main limbs will grow to an inordinate length that will necessitate extra heavy winter pruning.

At the South well-grown peach trees will begin to bear at about three years from time of planting.

For distant shipment fruit cannot be allowed to fully ripen on the trees. The best stage for picking is after it has obtained full size and color, but two or three days before it begins to soften. The fruit on a tree cannot all be picked at once, but should be gone over as often as every second day in order to secure it all in the best condition. It should be handled very carefully to avoid all bruising. Picking baskets should be lined with cloth or still better fruit

should be picked in smooth buckets, and hauled direct to the packing house without receiving other handling.

At the packing house the fruit is sorted into two or more grades, and then packed for shipment. The package most used at the South is a light crate, holding six four-quart veneer baskets. If the market is more than twenty-four hours distant, refrigerator transportation is almost essential. With proper refrigeration peaches may safely be shipped for four or five days, or even somewhat longer. To secure the best results it is of great importance to get the fruit into the cars as quickly as possible after it is picked. Early failures with refrigeration were largely due to the attempt to refrigerate fruit which was already overripe. Peaches are usually consigned to fruit dealers to be sold on commission. They are so perishable that dealers dislike to take the risk of buying them at the point of shipment. However, buyers visit the principal producing centers each season, and often take considerable quantities.

At the South peaches are mostly grown for shipment in the fresh state. At some points canning and evaporating plants have been established, but these, as a rule, only work up the poor grades. In the more remote country districts peaches are still sometimes fermented and distilled into brandy.

An immense number of varieties are in cultivation, but they can be grouped into five principal classes or races. First, the Persian, which includes the Crawford, and many other varieties that have been longest in cultivation at the North. Second, the North China

race, which are mostly descended from the Chinese Cling; this includes the Elberta and many others most popular in the middle South. Third, the so-called Spanish type, including certain kinds derived from Florida seedlings, which were supposed to be of Spanish origin. This race is of less importance than the other two, but is adapted to a somewhat more southerly region. They are mostly grown in the latitude of north Florida. None of these races succeed well in the peninsula of Florida, nor in South Texas; for these regions two other races have recently been developed that came originally from South China. The Chinese Honey and its descendants are rather small, long, pointed peaches, with a sweet but somewhat insipid flavor. The Peento type are descendants from a variety of that name, which, unlike the Honey, is broad and flat in shape. Varieties of these two types can be grown throughout the orange belt of Florida and succeed to some extent in Cuba and other tropical countries. No detailed description of the different varieties can be attempted here, but the reader is referred to the Reports of the Georgia and Florida Horticultural Societies.

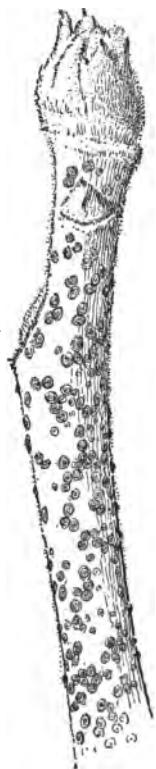
Diseases and Insects. — The most serious fungous disease at the South is the brown rot (*Monilia*). If the weather is wet during the ripening season, the loss from this cause is liable to be very great. It is always worse on low, moist land and on trees that are making a vigorous growth. To guard against rot orchards should be given such treatment as will induce only a moderate growth, just enough to keep the trees in a healthy normal condition. Rapid growth

in a bearing orchard is not desirable. Thorough spraying with Bordeaux mixture gives a large measure of protection from rot, but in very unfavorable seasons, or on rankly growing trees, it cannot be depended upon to entirely prevent it. Peach foliage is very susceptible to injury from copper compounds, so that a very weak Bordeaux must be used. Two pounds of copper sulphate and six pounds of lime to a barrel of water is the formula usually recommended for peaches. To be effective, spraying must be given early in the spring, as soon as the blossoms fall. In fact, one spraying before the buds open is advisable. Subsequent applications will depend, to some extent, upon the weather. If the weather is wet, more spraying will be required than when dry. Another necessary precaution is to remove all dry, so-called "mummied" fruits of last year's crop and destroy them, for it is on these "mummies" that the fungus passes the winter.

Next in importance to the rot is the curculio, a small beetle which stings the young fruit and deposits an egg which hatches into a small, white, footless grub, that feeds within the tissues of the growing fruit, either destroying it entirely or, if the egg has been laid later in the season, causing it to ripen prematurely and, when cut, disclosing the rotting cavity in which the grub is feeding. These wormy peaches are well known by every one who has handled this crop. Adding two ounces of Paris green to the barrel of Bordeaux mixture that is used for the first spraying after the falling of the flowers will kill a certain proportion of the adult beetles, as they feed

to some extent upon the young, tender foliage. But this spraying cannot be depended upon to fully protect the crop. The beetles have a habit of falling from the tree when disturbed. This fact is taken advantage of for destroying them. Sheets are fastened over light frames that are made with an opening on one side so that they may be slipped about the trunk of the tree ; the tree is then jarred sharply, the beetles falling upon the sheets, where they may be gathered up and destroyed. This work is best done early in the morning, since the beetles fly too quickly during the heat of the day. Curculio catching should begin as soon as the young fruits are well formed, and the trees should be gone over every morning as long as the insects are found in any quantity. In some seasons they will be practically all caught in three weeks and at other times it will be necessary to continue the catching almost to the time for gathering the fruit. This is a laborious and expensive business, and is not undertaken by all growers. It is, however, the only method by which immunity from this pest can be secured, and it is found to pay well by those who have followed it most thoroughly.

The San José scale (*Aepidiotus perniciosus*) is an insect coming originally from China that first attracted attention in this country in the neighborhood of San José, California. It has since spread to practically all fruit-growing sections, usually having been carried on infected nursery stock. This fact more than anything else has led to the enactment in most of the states of stringent laws governing the inspection of nurseries and the traffic in and importation of nursery



The San José Scale.



A Curculio Catcher.

stock. This insect attacks practically all of the deciduous fruit trees and many ornamental trees and shrubs, covering the bark with a grayish scurfy coating. It is especially injurious to the peach, since, when present in great numbers, it quickly lowers the vitality of the tree, frequently killing it outright by the second year. Many fine orchards in all parts of the country have been ruined by this insect. For a long time entomologists were at a loss to determine the original home of this insect, as it is now so widely scattered in all parts of the world. Since this has finally been determined, great efforts have been made to find and introduce its natural native enemies, but so far the practical results obtained have not equaled the expectations that were warranted by the success of such importations in other cases. The usual methods employed for combating this most serious pest are the use of contact poisons for spraying and washing the trunks, or fumigation with hydrocyanic gas under tents. The latter method is cumbersome and expensive, so reliance is usually placed on spraying. Various substances have been widely recommended for this purpose and have been used with more or less success, particularly whale-oil soap and kerosene and crude petroleum, both in emulsions and mechanical mixtures. On the whole, however, the best and safest results are found to follow the use of the sulphur-lime spray (see page 97). Two applications are best, one in the fall as soon as the leaves are off and another in the spring before the buds open. As in most spraying operations, very thorough work is necessary, since it is

only those scales that are actually covered by the mixture that are killed.

The next most serious peach enemy is the root borer. This is the larva of a small moth which lays her eggs on the bark at the foot of the tree. When the young hatch, they bore into the bark and range downward, feeding on the soft layer between the bark and the wood. They are often numerous enough to do considerable damage, sometimes even girdling the tree and killing it outright. Many preventive washes have been tried with the idea of deterring the insect from laying her eggs on the tree, and it is probable that some of them are more or less effective; but careful experiments show that they cannot be relied upon. Perhaps as good a one as any is to paint the trunks of the trees, in early spring, with a heavy Bordeaux mixture, to which has been added six to eight ounces of Paris green to the barrel. The lime of the Bordeaux mixture acts to some extent as a deterrent, and the Paris green will kill some of the newly hatched larvæ while attempting to bury themselves in the bark. Another expedient is to mound the dirt up well around the trunk of the trees in early spring, before the eggs are deposited. This forces the insect to place her eggs high up on the tree, where the bark is too hard to be easily penetrated by the young larvæ. After all these precautions have been taken, however, it is still necessary to go over the orchard two or three times each summer and dig out the borers with a sharp knife. On removing the dirt from the base of the tree, they can be easily located by the gum and

sawdust that exudes from the mouth of their burrows.

The peach yellows that has killed so many orchards at the North is almost unknown at the South, but a somewhat similar disease, known as rosette, has been quite destructive in restricted localities. Infected trees can be told at quite a distance by the yellowish color and the manner in which the leaves are crowded at the ends of the twigs. This, like the yellows, is a functional, non-parasitic disease. No remedy is known. Diseased trees should be promptly dug up and destroyed.

Plums (*Prunus ssp.*).— The remarks already given in regard to peaches will nearly all apply with equal force to plums, since the two crops require very similar conditions and management and are liable to the attacks of the same diseases and insects. If anything, plums may be planted on rather heavier soils than peaches. The cultivated varieties of plums differ much more widely than peaches, since they are derived from a number of distinct species. The Japanese plums, which are supposed to belong to *Prunus triflora*, are the most important race for the Southern states and include such well-known market kinds as Abundance, Burbank, and Kelsey. Next in importance come the Wild Goose class (*Prunus hor-tulana*). Following these are the native Chickasaws (*Prunus angustifolia*), many of which have been brought into cultivation. The European plums and prunes (*Prunus domestica*), which are so largely grown in California, do not succeed well at the South, and are rarely found there. The many native varieties

of Northern plums (*Prunus Americana* and *Prunus nigra*) are also but little planted.

A few varieties of plums root readily from cuttings, and one of these, the *Mariana*, has been extensively used as a stock on which to bud the other kinds. At the present time most commercial plum orchards in the South are on these stocks.

Besides the diseases and insects discussed under peaches, plums are subject to another serious trouble, known as black knot (*Plowrightia*). This is a fungous parasite causing unsightly black, gall-like swellings on the twigs and branches. When these become numerous, they greatly sap the vitality of the tree, and in extreme cases even cause its death. It can be quite thoroughly controlled by carefully pruning out the diseased branches and spraying the tree in early spring with Bordeaux mixture in order to prevent new infection.

Neither apricots nor cherries, the other two important stone fruits, succeed well at the South. Apricots bloom so early as to be very subject to injury from late frost; while climatic conditions do not seem favorable to the growth of cherry trees, and it is useless to plant them south of Tennessee and Kentucky, except in the mountains and the red clay foothills of the Piedmont region.

Apples (*Pyrus malus*). — At the South apples do not have the same preëminent commercial importance as at the North, but they can be grown, at least for home use, in practically all parts of the cotton belt. A few varieties will even grow and bear fruit along the Gulf coast and in Florida, though

they give plain indications that the surroundings are not congenial.

Apples grow best on rather heavy soils, those of limestone origin being particularly adapted to them. They are sometimes budded in the same manner as peaches, but it is more usual to propagate them by root grafting. Apple seedlings are taken up when one year old, the roots cut into from one to three pieces, and the scion of the desired variety is whip-grafted into this piece of root. These grafts are planted rather deeply in nursery rows, so that the point of union is well covered with earth. They are usually allowed to grow two years in the nursery, but some orchardists prefer planting one-year-old trees.

The cultivation and care of an apple orchard is much the same as with the peach, except that less pruning is required and that on strong, moist lands it is permissible, after three or four years, to seed the land down to grass or clover.

Several hundred varieties of apples have been listed in catalogues, and more or less cultivated, but comparatively few of these have any commercial importance. Many of the best-known Northern varieties do not thrive well at the South. Of the better-known kinds, Red Astrakhan and Red June for early, and Winesap and Ben Davis for late, kinds may be safely planted.

Apples are subject to the attacks of a long list of diseases and of insect troubles. There are borers which attack the roots and trunks, and cankerworms to destroy the leaves. The woolly aphid causes distortions and gall-like swellings on the roots. This

is apt to be a rather serious pest and is frequently introduced on the roots of young trees from the nursery. Such trees should never be planted. This trouble may be partially cured by removing the soil from the roots and applying a liberal application of ground tobacco stems and again covering with dirt.

Everything considered, the codling moth is the most serious pest of the apple. This is a small brown moth that lays an egg in the calyx of the young apple just after the flower falls. The egg soon hatches into a minute grub that bores down into the fruit, usually working in or near the core. Such wormy apples are, of course, worthless for market. The standard remedy is to spray thoroughly with Paris green, just after the flowers fall, and before the young fruits get heavy enough to turn down. If a drop of the poison spray chances to lodge in the calyx, the Paris green will remain there and kill the young grub as it tries to eat its way into the interior.

Two sprayings should be given at intervals of a week or ten days and the work should be done as thoroughly as possible in order to make sure that each apple receives its drop of poisonous liquid.

Another very serious apple trouble is the fungous disease known as scab (*Fusicladium*). This forms brown, unsightly blotches on the fruits and seriously injures their keeping qualities. It also attacks the leaves and the young twigs. The fungus which has wintered over on the twigs becomes active early in the spring, and if the weather is damp and rainy at blooming time, it may cause the blasting of the flower clusters and prevent the setting of fruit. Thorough

spraying with Bordeaux mixture is the recognized remedy. To be effective this must begin early in the season. The first application should be given before the flowers open and a second as soon as the petals have fallen. As a rule it is not wise to spray plants of any kind when in full bloom as there is danger of interfering with pollination. Usually a third and fourth application should be given at intervals of ten days to two weeks. In practice Paris green is added to the Bordeaux mixture for all except the first application, the combined spray thus serving to prevent injury from the codling moth and from the cankerworm and other leaf-eating insects and at the same time giving protection from scab and other fungous troubles.

At the South bitter rot (*Sphaeropsis*) must be included among the very serious apple diseases. It attacks the unripe fruit while still hanging on the tree, covering it with large blackened areas. If examined closely, the surface of these areas will be found to be more or less thickly covered with minute pustules that break up through the epidermis of the leaf. These are the fruiting bodies of the fungus and contain the spores by means of which the disease is disseminated. The same fungus also attacks the larger branches, killing the bark and causing sunken, more or less distorted areas called cankers. It is here that it passes the winter. The careful cutting out of all such centers of contagion during the winter together with repeated sprayings with Bordeaux, as recommended for the scab, will largely prevent injury, but the disease is a very difficult one to

fully control. Some varieties are much more subject to it than others, and only those with some degree of immunity should be selected for planting.

The serious disease of pears known as blight or fire blight also attacks apples and often causes much damage by destroying the flower clusters and the small twigs that bear them. This is a bacterial disease, and the contagion is conveyed from diseased to healthy flowers by the bees which visit them in such numbers. It will be discussed more fully as a pear disease. No remedy can be given except to cut out all diseased flower clusters as soon as they can be detected and to see that no neglected pear trees are allowed to stand in or near the apple orchard.

At the South apple trees are often seriously damaged by green aphids. These are little soft-bodied sucking insects that multiply with exceeding rapidity. They may be often seen entirely encrusting all the young growing twigs. A tree so infested stops growing and is greatly enfeebled. Spraying with kerosene, either as an emulsion or as a mechanical mixture with water, is the usual remedy, but it is not fully satisfactory. Apple foliage is easily injured by kerosene. The mixture cannot be used if stronger than ten per cent and even then care must be used not to apply it too heavily. To be effective the spraying must be repeated at frequent intervals, since it is always impossible to kill all of the insects, and the few that are left multiply so rapidly as quickly to reinfect the tree.

Apples are sometimes attacked by the San José

scale, though they are less susceptible than the peach, pear, or plum. They are also often infested by another scale, the oyster-shell bark louse. The same line of treatment suggested for the San José scale on peaches will be effective for any of the scales found on apples.

The apple leaf rust (*Gymnosporangium*) is another disease that should be mentioned. It is a fungous disease causing conspicuous yellow spots on the leaves. On the under side of these spots clusters of minute horn-shaped receptacles appear that are filled with spores. This disease is a peculiar and interesting one, since the fungus which causes it passes through two very distinct stages. The spores formed on the apple leaves will not grow again on the apple, but if blown to a red cedar they quickly germinate and form small galls on the twigs, which the following spring develop into the unsightly orange-colored masses, usually known as "cedar apples," that are such familiar objects wherever apples and red cedars occur in the same neighborhood. It is the spores produced on these "cedar apples" that again infest the young apple leaves and cause the yellow rust spots. Cutting down all the cedar trees in the neighborhood of an apple orchard is the surest remedy for this trouble. Spraying with Bordeaux mixture at the time that the "cedar apples" are maturing spores will also give some protection. Many varieties of apples show a marked immunity from this disease. Red Astrakhan, Winesap, and Ben Davis are seldom or never attacked by it, while Red June, Jonathan, and many other varieties are

seriously injured in all regions where the red cedar is common.

Pears (*Pyrus ssp.*).—The varieties of pears mostly cultivated at the North are of European origin, and these, as a rule, do not succeed well at the South. All the varieties of the Oriental race, however, are perfectly well adapted to Southern conditions and a few of them are extensively grown for market. Unlike the European kinds which do best on strong clay-loam soils, these thrive in even the lightest sands and can be successfully grown throughout the cotton belt, along the Gulf coast, and even in peninsular Florida. To succeed, however, they must be budded on Oriental roots. They will not thrive if propagated on European roots or on the quince.

Some fertilizer must be used on very light soils to secure sufficient growth, but, as will be more fully explained in discussing blight, great care must be taken not to overfertilize.

It is usual to give clean cultivation during the first two or three years. After this, custom varies; some growers, especially on the heavier soils, preferring to plant the ground to some cover crop or even let it grow up to grass.

Unlike most other fruits, pears do not develop their best quality if allowed to hang on the tree until entirely ripe. They should be picked when fully grown or as soon as the seeds have hardened and be placed in a close dark place to ripen. The rule usually followed in picking is to take them as soon as the stem will part readily from the tree when the pear is lifted. If allowed to tree ripen, many varieties

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become dry and tasteless, while others soften and rot at the core, thus becoming worthless.

Like the apple, pears are subject to the attacks of the codling moth and also to a scab fungus. These may be controlled in the same way as suggested for apples by spraying with Bordeaux mixture just before and with Bordeaux and Paris green just after blooming.

San José scale attacks pears in common with the other deciduous fruit trees and should be treated as previously indicated.

Pears are also subject to a leaf-spot fungus (*Entomosporium*) which does much damage by causing the premature falling of the leaves. Some varieties are very susceptible and are often completely defoliated by midsummer. This prevents the formation of fruit buds, and the crop for the following year is lost. Other kinds show a marked degree of immunity and are usually but little injured. The spraying with Bordeaux recommended for scab will do much to hold this disease in check also.

Blight, or as it is sometimes called, fire blight, is by far the most serious disease of pears. It is caused by bacteria which attack the tender growing tissues, especially of the cambium, which lies between the bark and the wood. The stigmas of the open flowers are also very liable to attack and in the great majority of cases infection takes place in this way through the flowers. The usual course of the disease is as follows : when the sap first stirs in the spring on certain old blighted areas, where the disease has held over from the previous year, the bark

exudes drops of a sweet sticky liquid that is simply swarming with the blight germs. Other food being scarce, bees are attracted to this sticky exudation and become smeared with it. When they afterward visit the first open flowers, they carry the germs, which find a favorable place of growth on the moist stigmas of the pistils. They multiply and find their way down through the soft tissues so rapidly that in the course of one or two days the entire flower looks limp and watery, and it soon blackens and shrivels. From the flower stem the disease quickly makes its way to the soft cambium of the fruit spur, and spreads from this downward to the larger limbs on which it is borne. The disease usually continues to spread rapidly as long as the tree is in an active growing condition, and it often happens that the disease, gaining access to a large limb from some small fruit spur, completely girdles it, and thus causes the sudden dying of all that part above the point of infection. If, as sometimes happens, the diseased fruit spur springs directly from the main trunk, the entire top of the tree may suddenly die. When the trees stop growing and begin to harden up the new wood in the great majority of cases, especially on the twigs and small branches, the disease dies and a sharp line of demarcation begins to separate the dead from the living wood. On the trunks and larger limbs, however, there are always certain places where it continues to grow slowly, and it is by means of these "hold over" cases that the disease passes the winter, and starts a fresh outbreak the following spring. The "blossom blight"

above described is by far the most common form, but the disease may also be conveyed by the bites of insects to the young leaves, stems, or fruits. It does not, however, seem to be able to pass through the unbroken cuticle which is nature's protective covering to guard against such infections.

No remedy for this disease is known, and no spray or other application has been found that is of the slightest use in controlling it. Cultural methods, however, may do much to minimize the losses occasioned by it, by taking advantage of the fact that it spreads fastest when the tree is making the rankest, most vigorous growth, and that it practically dies out as soon as that growth begins to harden. A pear orchard that is attacked by blight should be at once seeded down to grass, or some cover crop, and should be given phosphatic fertilizers, but no nitrogen, in order to induce the early hardening of the wood. Especially after the trees reach bearing age anything that would induce a rank, sappy growth should be carefully avoided. Sporadic cases that occur in young trees should always be promptly cut out, taking care to cut well in advance of the diseased area. In a bearing orchard it will do little good to attempt cutting while an outbreak is actively in progress, but when it is over the dead wood should be cut away and careful search made for all living "hold over" cases. These should be cut out with great care, and the orchard should be inspected frequently, with the hope of detecting and removing all of them. In starting a young orchard it is also wise to prune back very

low, and then allow three or four leaders to form instead of one. This does not make as handsome a tree, but in case blight infests one of these leaders it can be cut away without losing the entire tree. It is also best to carefully prune off all fruit spurs that form on the trunk and larger limbs, thus confining the flowers, which are such a source of danger, to the twigs and smaller branches. There seems to be a certain periodicity with this disease, and in occasional years heavy losses will occur, notwithstanding all these precautions. Ordinarily, however, profitable crops can be secured if they are carefully attended to.

The quince (*Cydonia*) and the loquat (*Mespilus*) are two fruits related to pears and apples that are considerably grown in some parts of the South, but neither is of much commercial importance. The ordinary, or French, quince does not thrive well, except in the more northern districts, but the large, coarse Chinese quince is at home in all parts. It is used, like the other, for preserving, but has quite a distinct flavor. The loquat, or medlar, sometimes erroneously called "Japan plum," only occurs in Florida and along the Gulf coast. It is quite abundant in the neighborhood of New Orleans. As it blooms in the fall, and ripens its fruit in early spring, it is a welcome addition to the home garden in those regions where it can be grown, but it cannot endure much cold. It also thrives well in the tropics.

The dwarf June berry, or service berry (*Amelanchier*), is another little fruit belonging to the apple and pear family that is often found in Southern

gardens. It is locally called a currant, but it does not compare with that favorite Northern fruit in flavor or usefulness.

Of the other small fruits strawberries and blackberries are the only ones that can be successfully grown. Raspberries, currants, gooseberries, and cranberries all fail except in the mountainous districts.

Strawberries (*Fragaria*) succeed well in all parts of the South, as also in Cuba, Porto Rico, and other tropical countries. They are grown extensively for Northern shipment, and, in fact, in certain regions they constitute the chief market crop. Refrigerator transportation must be utilized to reach points more than twenty-four hours distant. A great number of varieties are in cultivation, and various cultural methods are used, but the subject is too large to be considered in detail here.

Blackberries (*Rubus*) are of much less commercial importance than strawberries. Some, at least, of them can be grown successfully in all parts of the Southern states. The varieties in cultivation are descended from a number of wild species. They may all be classed in two groups, the high-bush blackberries and the trailing blackberries. The last are usually called dewberries.

Grapes (*Vitis*). — Some of the many kinds of grapes can be grown successfully in all parts of the Southern states and even in favored localities in the West Indies. In no part of the South, however, do they have the same commercial importance as along the shores of Lakes Erie and Ontario or in California.

Grapes will grow under a great variety of soil and

climatic conditions. Most of the kinds do best on strong, well-drained limestone soils and in a dry rather than a wet climate. Frequent rains and a moist, muggy atmosphere, especially as the fruit reaches maturity, always promote the many fungous diseases to which this crop is so susceptible. The common European practice of planting on hillsides too steep for cultivation to other crops is seldom followed in this country, not so much because grapes cannot be made to thrive in such locations as because the expense of cultivation is much greater than on more level land. Good drainage is, however, always important, and a southeast exposure, where the dew dries early, is to be preferred to a northern one. Grapes require plenty of potash and phosphoric acid, and where these substances are lacking they should be supplied in commercial fertilizers; but nitrogenous manures should be avoided as they promote a tendency to disease. Vine roots seem to have a considerable power of utilizing the insoluble phosphates. No vines grow better than those having old bones buried about the roots.

Grapes are mostly propagated from cuttings, the young plants being planted in the vineyard when from one to two years old. They are usually planted at from six to eight feet apart, and the ground should be given frequent but shallow cultivation in order to always keep it clear of weeds and grass. Cover crops are seldom used in the vineyard, but at the South some kind of winter cover crop would undoubtedly be of great benefit in protecting the fertility of the soil. The California method of training which

allows the vines to fall over on the ground will not answer at the South on account of the summer rains, but it is necessary to tie the vines either to stakes or to some form of wire trellis. Everything considered, the horizontal three-wire trellis is to be preferred, since the fruit hangs under the shelter of the leaves and is more protected from sun and dew.

Most kinds of grapes require heavy annual pruning in order to produce profitable crops. A number of different systems of pruning are in vogue, but the so-called long-arm renewal system is best adapted to Southern conditions. During the first season all laterals are pinched out, and the vine is trained to a single stem. When this reaches the height of the trellis, the terminal bud is pinched out to force branching. No further attention is required till the winter pruning, when all but the two best branches are cut away. These are tied down to the central wire of the trellis and are cut back to three or four buds in order to prevent overbearing. Each of these buds will push a strong new shoot in the spring, which in most cases falls over the side wires and supports itself without the necessity of tying. The fruit is borne on these new shoots, each one producing an average of three bunches. All shoots starting from the lower part of the main stem should be pinched off. The next winter the two best shoots are again selected, preference being given to those starting farthest back near the old cane, and all others are cut away. This time the bearing canes may be left longer than the first year and by the third year they may be left long enough to meet with those of

the next vine, thus making a continuous line of bearing wood for the full length of the trellis.

Grapes must hang on the vine till fully mature, as they do not ripen after gathering. Maturing at the South during the heat of midsummer, they do not keep like the Northern grape that ripens in the cool weather of fall, and they must be marketed quickly, refrigerator transportation being necessary for distant shipments.

At the South grapes are mostly grown for use in the fresh state, but in a few sections wine making has become a successful industry. Many families also make it in a small way for home consumption. The kinds mostly used for wine making are the Concord, the Herbemont, and the Scuppernong.

The varieties of cultivated grapes are very numerous and differ widely in character and adaptability to different cultural conditions. They are descended from a considerable number of wild species, and they are usually classified according to their botanical relationship. The most important that have become the parents of cultivated kinds are *Vitis vinifera* of Europe, *Vitis Labrusca* of the northeastern United States, *Vitis aestivalis* of eastern America, *Vitis Bourquineana* of the southeast (known only in cultivation), *Vitis rotundifolia* of the southeast, and *Vitis Linsecomii* of the southwest. Besides the direct descendants of these different species much attention has been given to hybridizing, and some of our best varieties are multi-hybrids, combining the characteristics of several of these original strains. The name of Rogers will always be associated with

the delicious but unfortunately rather delicate kinds produced by combinations of the *vinifera* and *Labrusca* types, while the achievement of T. V. Munson of Texas in producing an entirely new race of grapes, better adapted than any of the old ones to southwestern conditions, by using the native post-oak grape of Texas as the foundation for his crosses, is one of the most notable in the entire history of plant breeding. A wild grape (*Vitis Carabœa*) grows abundantly in many parts of the West Indies. It is exceedingly vigorous and the fruit is of fair quality. It could doubtless be used with equal success as the basis for a race of grapes entirely adapted to tropical conditions.

The *vinifera* or European kinds are practically the only ones grown in Europe and in California. All of the raisin grapes and many of the best wine and table grapes belong here. They require a warm, dry climate in order to succeed well, and unfortunately none of them are fully successful at the South. In a humid climate they are very subject to mildew and to other diseases, and everywhere they are exceedingly susceptible to the attacks of Phylloxera.

The *Labrusca* varieties are the ones most generally grown in the northeastern United States, and they include such well-known kinds as Concord, Catawba, and Niagara. They can be grown as far south as the Gulf coast, but are not fully successful in peninsular Florida and are probably not adapted to tropical conditions. They are good growers and are comparatively resistant to most grape disease,

but at the South they prove very susceptible to root rot, and vineyards are apt to be short lived.

The *aestivalis* varieties are of comparatively little importance, though some of them are valuable for wine. Vines of this type and of the closely related *Vitis rupestris* are very resistant to the Phylloxera, and they have been very widely used in Europe and California as stocks on which to graft the susceptible *vinifera* varieties.

The *Bourquineziana* varieties also constitute a small group, but they are important at the South from their power of resistance to the insidious root-rot disease. The Delaware, everywhere so well known as one of the best of American table grapes, and the Herbemont, which makes one of the finest American wines, are the two principal varieties of this class.

The *rotundifolia* varieties are all natives of the Southeastern states and thrive best on the moist, sandy soils of the coast region. They are rampant growers, easily climbing to the top of the tallest forest trees. The fruit is large and juicy but thick skinned. It is produced in small, irregular clusters and not in symmetrical, compact bunches, as in the other races. Unlike the bunch grapes it requires little or no pruning, the vines being allowed to run at will over large arbors. The Scuppernong is the best-known kind. It is a light-colored grape, while all the other varieties are black. While of no great commercial importance, it is very widely planted at the South for home use and domestic wine making; in fact, no Southern home is considered complete without its Scuppernong arbor.

The *Linsecomii* varieties have all originated with Mr. Munson in Texas. They are especially adapted to southwestern conditions, though they succeed well in most other parts of the South. They contain some very fine table varieties. Owing to their wide range in season of ripening, they have considerably extended the Southern grape season. The adaptability of these kinds to tropical conditions has not yet been determined.

Grapes are subject to a great variety of insect pests and fungous diseases. Owing to the importance of the vine industry in Europe and to the fact that it has been three times seriously threatened with annihilation, owing to the importation of American diseases (powdery mildew, downy mildew, and *Phylloxera*), attention was early called to these troubles, and they have been more exhaustively studied and published on than the diseases of any other cultivated plant. The resulting mass of literature is so enormous as to be absolutely bewildering. Only the more important troubles can be touched on here. For practical purposes it is only necessary to know that most of the fungous diseases and leaf-eating insects can be held in check by persistent spraying with Bordeaux mixture and Paris green. This treatment is strongly recommended wherever grapes are grown in the humid regions. The first spraying should always be given before the buds open.

Powdery mildew (*Uncinula*) is a superficial fungus that forms a white coating over the leaves, fruit clusters, and young stems. It is very injurious to the European varieties, but rarely does much

damage to American kinds. Dusting with sulphur is a better remedy than the Bordeaux for this disease.

Downy mildew (*Plasmopera*) is a far more serious trouble than the previous kind. This fungus grows within the tissues of the leaves, sending out its fruiting branches through the stomata on the under surface, where they form a delicate downy or frostlike coating. The affected leaves soon die and fall. It also attacks and rots the young fruit clusters. Fortunately, it can be controlled by thorough treatment with Bordeaux mixture; in fact, it was against this disease that this famous remedy was first employed.

Black rot (*Guignardia*) should probably be considered the most serious grape disease in eastern North America. It grows on the leaves, causing a conspicuous brown spotting, but its chief injury is to the fruit. The infested fruits blacken and shrivel into hard, unshapely, persistent masses, which are covered with prominent pustules containing the spores. This makes ragged, unsightly bunches that are unfit for market. In severe attacks, all the fruits on a cluster are frequently destroyed. Varieties differ somewhat in susceptibility, but all of the bunch grapes are more or less subject to attack, the *rotundifolia* type alone having any real immunity. Thorough early and repeated spraying with Bordeaux, especially if continued from year to year, will usually hold this disease in check, but it is notoriously difficult to control, and careless spraying is only wasted labor.

Ripe rot (*Glæosporium*) is another very serious

trouble at the South. It attacks the fruits just as they are beginning to ripen, causing them to become discolored and often somewhat swollen. The diseased fruits are covered with pimple-like pustules, as in the black rot; but unlike those attacked by that disease, they do not dry down and persist, but soon soften and fall from the cluster. The disease often develops after the fruit is picked and while on its way to market; baskets of grapes that seem perfectly sound when packed, opening up forty-eight hours later in a worthless, unsalable condition. From the berries the fungus soon invades the stems of the cluster. Instead of remaining limber and pliable, as in healthy clusters, such infected stems dry down hard and brittle, so that even the sound berries are easily jarred off, and the clusters, when they reach market, cannot be handled without shattering. It is this shattering that has given Southern grapes so poor a reputation in the markets and has done more than anything else to make the industry unprofitable. Spraying with Bordeaux is not admissible for some weeks before the ripening of the fruit, since it stains the clusters and makes them unfit for use. It therefore cannot be used as a remedy for this disease. The ammonia-calcium solution of copper carbonate may be substituted for it with some success, but it by no means fully prevents the trouble. Training on a horizontal trellis so that the fruit is protected from the sun and dew by the foliage gives more relief than anything else, but no really successful treatment for controlling this disease has yet been devised, es-

pecially if the weather is damp and showery when the grapes are ripening.

Root rot is an obscure trouble which has not been sufficiently studied, and its real cause is not understood. A whitening of the layers between the outer and inner bark is always noticeable, and the small roots gradually die and rot; but so far it has not been possible to connect the disease with any specific fungus. It occurs in all parts of the South, especially in the dry hill lands, and has been the cause of the early death of a great number of vineyards. The *rotundifolia* grapes seem to be entirely immune to this disease. The *Bourquineana* varieties, while not fully immune, show a pronounced power of resistance, while all the other classes are about equally susceptible. It is probable that grafting these other kinds on some strong-growing, resistant kind like the Herbemont would do much to obviate this trouble and to prolong the life of Southern vineyards. The Delaware, although a slow grower and usually considered delicate, has a pronounced power of resistance, and in many parts of the South it will continue to live and bear crops long after the Concord, Ives, and other strong-growing kinds have been entirely destroyed.

The Phylloxera is a plant louse that occurs in two forms: one causing small galls on the leaves, and the other living on and causing distortions of the roots. It is the root form that does most damage and causes the death of susceptible kinds. It is a native American insect, and all the American species of grapes have developed a greater or less immunity to it; so

that while it may be able to live on them, it causes but little injury. The European *vinifera* varieties are all, however, very susceptible, and to grow them successfully where the Phylloxera occurs, they must be grafted on roots of some resistant American kind. This is now very widely done in both Europe and California. None of the kinds usually grown at the South are materially injured by this insect.

The great number of leaf-eating grape insects can all be more or less successfully controlled by the use of Paris green, which is best applied in connection with the Bordeaux-mixture sprays.

Persimmons (*Diospyros*). — The Japanese persimmon is another fruit of some importance that grows well in nearly all parts of the South. It is of rather recent introduction and so far has been slow in finding a place in the markets. The demand for it is, however, slowly increasing, and as it is of really high quality and keeps and ships well it will doubtless ultimately become one of the important commercial fruits. The trees are not hardy at the North, and they are sometimes injured in the South by exceptionally cold winters or especially by late cold snaps in the spring. Methods of cultivation are much the same as for as the peach though much less pruning is required. As the trees are slow growers they may be set as close as twelve or fifteen feet. There has been much confusion in regard to varieties and varietal names. About a dozen kinds are now in more or less general cultivation and can be secured of the leading Southern nurseries. The trees are sometimes injured by a serious blight, but

it has not been sufficiently studied to determine the real nature of the disease nor to suggest a remedy. A leaf disease also occurs, but on the whole this fruit is unusually free from serious troubles.

The native wild persimmons, so common throughout the South, are gathered and shipped to market from some sections. During recent years some attention has been given to selecting the best of these and bringing them into cultivation, but as yet this has not passed the experimental stage.

Subtropical Fruits

The various citrus fruits easily overshadow all the others that can properly be classed as subtropical. Of these oranges, pomelos (grape fruit), lemons, limes, and citrons are of most importance. Other subtropical fruits are the fig, pomegranate, and olive.

Figs (*Ficus*). — The fig must be classed as subtropical, although when in the dormant condition the tree will stand considerable cold. It can be grown with some success as far north as central Alabama and Mississippi, for although at this latitude frequently frozen to the ground by hard winters it sprouts readily from the roots and often bears fruit on these new shoots the first season.

The fig will grow on a great variety of soils, but if not naturally rich they should be well fertilized. It has a shallow rooting habit, and only very shallow cultivation should be given after the trees gain much size. Deep plowing is very detrimental. In fact, at the South the ideal location for figs is found

in the hard-tramped, clean-swept dooryard, where they receive no cultivation whatever, but where no grass or weeds are allowed to grow and where they are constantly enriched by ashes, soapsuds, etc. Figs always thrive admirably in dooryards, but there have been many failures when the attempt has been made to grow them under orchard conditions.

The fig, while widely grown at the South for family use, has never gained much commercial importance. The fresh fruit, ripening as it does during the period of midsummer rains, is too delicate for shipment under ordinary methods. Experiments have shown that with very careful handling it can be successfully shipped under refrigeration, but fresh figs are practically unknown in the Northern markets, and there is consequently no pressing demand for them. By proper effort a profitable trade in them could unquestionably be established, for no fruit is more keenly relished by those who have learned to know it. There is a limited industry in canning and preserving figs at a few points in the South. So far, very high prices have been maintained for these goods, and the demand for them is, consequently, not as great as it would otherwise be. It is an industry that is capable of very considerable extension. No commercial dried figs are made at the South, since climatic conditions are unfavorable and the varieties best adapted to drying do not thrive well.

The number of varieties known in different countries is very large, but only a few seem to succeed well at the South. Of these Celeste and Green

Ischia are the best for general planting. The Celeste is a small fig, but very sweet and delicious, and the tree is exceedingly hardy and productive. It is more planted than all the other kinds combined. It is an early fig, ripening during July. The Green Ischia is somewhat larger and later, ripening in August and September, thus making a desirable succession. It is of high quality and seems to be equally as hardy and productive as the Celeste. It is comparatively little known, but deserves to be much more widely planted. None of the varieties grown at the South produce fertile seed, since they all belong to the class that produces fruit without pollination. The wild pollen-bearing Capri fig, with its curious insect parasites, which convey the pollen to the hidden pistillate flowers, are therefore not needed. All the figs are readily propagated by means of cuttings.

Nematode root galls (*Heterodera*) constitute by far the worst disease of the fig. These trees are particularly susceptible to the attacks of this pest, which occurs so abundantly in all the sandier lands at the South, and it is probably responsible for most of the failures that have occurred with figs. The infested roots soon rot away, and the tree quickly loses vigor and finally dies. No practicable remedy is known. If nothing whatever is allowed to grow on the land for eighteen months, the nematodes will be exterminated by starvation. This probably accounts for the comparative immunity of trees grown under dooryard conditions.

The fig rust (*Uredo fici*) and another leaf disease (caused by *Cercospora Bolleana*) often do consider-

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able harm by defoliating the trees. These may both be kept in check by occasional spraying with Bordeaux mixture.

A stem borer is troublesome in Louisiana, and one of the native scale insects seriously injures the fig in Cuba. Neither insect has received much study.

Pomegranate (*Punica*).—This fruit has about the same range as the fig. The small amount of pulp surrounding the seeds contains a pleasant acid, and they are often used for making a cooling drink, but the fruit has no commercial importance. It is frequently grown in family gardens, but quite as much as an ornament as for its fruit.

Olives (*Olea*).—The olive is fairly hardy to cold and will grow and bear in the latitude of the Gulf coast. It has, however, been but little planted, and whether it can ever be of commercial importance is doubtful, as the climate does not seem to be well suited to it. The tree grows well in the West Indies. Some seen at Hope Gardens, Jamaica, fifteen years old, were thirty feet high, but for some unknown cause they had never borne fruit. The fact that it is not found in old Cuban gardens indicates that it will not succeed there, since it must have been early introduced by the Spaniards.

Oranges (*Citrus aurantium* and *C. nobilis*).—Oranges, while in reality tropical evergreens, are able to endure light frosts without injury, especially if in a half dormant condition, and they are, therefore, classed among the subtropical fruits. They are grown as far north as New Orleans and the Gulf coast of Mississippi and Alabama; but in this

Oranges.





latitude they are frequently injured by cold, and every few winters the trees are frozen to the ground. Sometimes in such cases they sprout again from the roots, but often they are killed outright. Even in northern peninsular Florida the orange industry, which was once so important, has been ruined by occasional severe winters, so that at the present time commercial orange growing in the southern United States is principally confined to the southern third of the Florida peninsula. Here it is a very important and growing industry, but the total output from the state is now less than it was before the disastrous freeze of 1894, and it is far less than from the great orange-growing district of California. The orange is at home in tropical countries, and it occurs abundantly in a half-wild state in all parts of the West Indies and Central America. Until recently, however, its commercial importance has not been realized in these countries, and its cultivation has received but little attention. Since the great freeze in Florida, and especially since the Spanish-American war, the possibilities of the business in regions absolutely free from frost has begun to attract the attention of enterprising Americans, and there are now considerable commercial plantings in Cuba, Porto Rico, and Jamaica.

The orange will grow and thrive on a great variety of soils and under most diverse climatic conditions. To secure a fruit that will keep and carry well, however, fairly dry weather is necessary during the ripening season, and it is the general consensus of opinion that fruit grown on rather light,

sandy soils carries better and is juicier and richer in flavor than that on heavy lands. The trees, too, are considered to be healthier and freer from foot rot on light, well-drained soils. In such locations, however, oranges require the liberal use of fertilizers, and their proper application taxes the skill of the grower to the utmost. Nowhere has the use and effect of fertilizers been more closely studied than by the Florida orange growers. While there is still much difference of opinion among them as to minor details, all are in agreement as to the main facts, which are: —

First, that abundant applications of potash are necessary to secure heavy, juicy fruit of high flavor and good keeping quality. It also seems to add to the vigor and disease-resisting power of the tree. If used too freely, the fruit may be a little too acid, but no other bad results will follow.

Second, phosphoric acid is also necessary, but in the case of the orange it seems to be less important than potash. It seems to induce greater fruitfulness, and no harmful results are likely to follow, even from its excessive use.

Third, while potash and phosphoric acid may be used freely with only good results, great care must be exercised in the use of nitrogen. If this element is not present in sufficient quantity, the leaves will be small and yellow, the tree will lack vigor, and the fruit will be small and poor. If too much is used, the leaves will be dark green and very large, wood growth will be stimulated at the expense of fruitfulness, and the fruit will be coarse, thick skinned,

and of poor keeping quality. If used in great excess, a serious disease known as "die back" will be induced, from the effect of which the tree may never completely recover. The source of the nitrogen used seems, too, to be a factor of importance. Stable manure should never be used in the orange orchard, and other organic sources of nitrogen, like cotton-seed meal and dried blood, are more dangerous than the mineral salts, like nitrate of soda and sulphate of ammonia. Even leguminous cover crops must be used with caution as their continued use in connection with other fertilizers has been known to occasion "die back." No hard and fast rule can be given governing the use of nitrogen in the orange orchard. The trees should be carefully watched and should be fed with it according to their evident needs. The amount to use will vary from time to time with the condition of the trees and of the weather. More can be used safely during the winter and in dry seasons than during wet midsummer weather, but it is always the part of safety to under rather than over feed with this substance. The total amount of fertilizer used by the Florida growers is very large. It may reach as much as fifty or even a hundred pounds per tree in the case of large old trees that are in heavy bearing, but young trees during the first year do not receive more than from one to five pounds. It is best to divide the amount to be used for the year into at least two applications, and some growers prefer as many as three or four, especially for the nitrogenous part of the fertilizer. Experience with fertilizers in the islands is not yet very

extended. So far it has been used in much less quantity than in Florida. Where heavy applications are required, the same precautions as in Florida will doubtless be necessary. Many of the earliest commercial plantings in these countries were made on rich, heavy sugar and banana lands with the idea that no fertilizers would be needed. It now seems probable, however, that the quality of fruit produced in such locations will not be such as to compete with that produced on lighter soils with intelligent fertilization and that the cost will really be greater, owing to the greater expense of cultivation in heavy lands.

Formerly nearly all oranges were grown on natural or so-called seedling trees. Now, as with most other fruits, commercial orchards are all planted with budded trees of named varieties. A considerable number of different stocks have been used on which to bud oranges and the other citrus fruits, and there is still considerable difference of opinion in regard to this very important question. The great bulk of the trees are, however, now grown on either sour orange, rough lemon, or *Citrus trifoliata* roots, although sweet seedlings (for soils not subject to foot rot) and pomelo seedlings both have their advocates. The *trifoliata* stocks are mostly used in the northern part of the orange belt, since their deciduous nature seems to check winter growth, rendering the trees more nearly dormant, and therefore more resistant to cold. Trees on this stock do not grow as rapidly as on the others, and some claim that this partial dwarfing makes the fruit thinner skinned and better in quality. The

rough lemon is a favorite stock with the nurserymen because it transplants easily and the young trees grow very rapidly. This rapid growth tends to make the first crops of fruit coarse and poor in quality, but this defect is remedied as the trees come into full bearing. It is probably one of the best stocks to use for light soils, especially in regions where there is little danger from frost. It is the general opinion, however, that this stock is not well adapted to heavy lands. The sour orange thrives in a great variety of soils, and it will undoubtedly stand more water and other unfavorable conditions than any of the others. It is very resistant to foot rot and is naturally very long lived. While trees budded on it do not grow quite as fast as on the rough lemon, it is greatly to be preferred on heavy lands, and on the whole it is probably the safest stock for general planting.

There is some diversity of opinion as to the best age at which to move orange trees from the nursery to the orchard. Many planters prefer large, heavy, two- or even three-year-old trees, and it is probably true that such trees give better results than in the case of most deciduous fruits. Everything considered, however, a well-grown tree that is from twelve to eighteen months from the bud will be more satisfactory and can be handled more easily and cheaply than the older, larger ones. Two- and three-year-old nursery trees are only too often the culled that did not make sufficient growth to be sold as yearlings. It is a great mistake, however, to plant a very small orange tree, or one so young that the wood is not thoroughly

hardened. In Florida orange trees are usually planted in winter, when in the most nearly dormant condition. They can then be handled much the same as deciduous fruit trees. They can, however, be successfully planted in summer by selecting a time when the growth is not active, but more care is required than in the dormant winter season. In moving orange trees they should always be heavily pruned, and if the weather is dry it is wise to clip off half of each remaining leaf with the shears in order to still further check transpiration. If the trees are entirely defoliated, the tendency is for new shoots to start too quickly before there is sufficient root development to support them. In the tropics it is often necessary to cut the roots about the young trees a week or ten days before moving them in order to check growth and render them sufficiently dormant, so that they can be handled with safety.

The proper handling, grading, and packing of oranges for market are matters of the greatest importance since the price received is largely dependent on the care and skill used. This fact seems to be more generally and fully appreciated by the California growers than by those in the South. Much of the reputation of California fruits has come from the fact that they are uniformly so well packed. Oranges for shipment should always be cut from the tree with the small clippers used for this purpose. If they are pulled, the skin will be broken at the point of attachment to the stem and decay is likely to follow. When first picked, the rind of the orange

is turgid and full of sap. In this condition it is easily bruised, so the fruit should be handled with much care and it should be "cured" by lying exposed to the air in the packing house for two or three days until this surplus moisture has evaporated and the rind becomes somewhat limp and pliable. It can now be handled and pressed closely in the boxes without injury. If the fruit is packed direct from the tree without curing, it will be more or less bruised in handling; the moisture given off will dampen the wrapping paper, thus favoring decay; and the shrinking of the fruit will make the box seem slack filled. Much of the complaint of oranges arriving in bad order comes from the careless disregard of this important matter of curing before packing. After the fruit has lain in the curing boxes long enough to handle well it is graded into brights and russets and the unmarketable culls are rejected. Each class is now assorted into certain standard sizes for convenience in packing. This is best and most accurately done by the use of some of the mechanical sizers now on the market. The oranges are rolled through the machine, the different sizes passing through different openings, and falling in separate receivers. Each orange is now wrapped in tissue paper that is usually marked with the distinctive brand or trade mark of the owner, and they are packed in the boxes, each size according to some definite plan that will bring them out evenly and smoothly at the top of the box. The box should be full enough so that considerable pressure is necessary in nailing on the cover. Small growers do not

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always pack their own fruit. It is often bought on the tree by shippers who run their own packing houses, or if not sold, it may be taken to some central coöperative packing house.

A large number of varieties are in cultivation, but for a detailed discussion of them the reader must consult some of the really excellent special works on orange culture. Two quite distinct groups may be recognized: the common or round orange (*Citrus aurantium*) and the Mandarin or kid-glove orange (*Citrus nobilis*). The Washington navel, which is the seedless orange so extensively grown in California, does not succeed well in Florida, and whether or not it will be a success in the West Indies is still an open question. In Florida each section has its favorite kinds, many of which have been selected from among the best native seedlings. In the comparatively new orange regions of the West Indies it is still difficult to decide what varieties it will be most profitable to plant. Many very excellent seedlings occur in these countries and it is probable that in the future each island may develop its own market varieties by selecting its best native seedlings.

The orange is subject to a considerable number of serious diseases and insect pests, only the more important of which can be briefly considered.

The "die back" has already been mentioned in the discussion of fertilizers. It is a functional trouble not caused by any parasitic organisms but resulting from some derangement of nutrition. It is usually caused by overstimulation with nitrogenous fertilizers. The leaves, which are at first very large and dark green,

become crumpled and mottled with yellow, the twigs exude drops of gum, and these symptoms are followed by the more or less extensive dying back of the branches. In the case of severe attacks the tree may ultimately die, but more often it lingers on in an unthrifty and unprofitable condition. Such trees may ultimately be restored to health by pruning out the diseased wood and giving great care to fertilizing and cultivation in order to carefully avoid the exciting cause. When an orchard is seen to be threatened with "die back," cultivation should be stopped at once so that the grass may grow and thus take up some of the excess of nitrogen, and some benefit may be derived from additional applications of potash and acid phosphate, which would tend to restore a proper balance in the food supply.

Foot rot, or *mal di gomma*, as it is called by the Italians on account of the flow of gum which accompanies it, is an obscure disease, the cause of which has not been clearly ascertained. It causes the dying of more or less extensive areas of the bark usually at or near the crown of the tree. As a rule it is worse on wet, heavy lands. The sweet orange, when on its own roots, is particularly susceptible to this disease, while the sour orange is quite resistant. The disease often girdles and kills the trees, but it is by no means always fatal, and old trees are often seen still fairly thrifty and bearing heavy crops while their bases are badly scarred by old attacks of this disease. Serious losses can usually be avoided by giving good drainage and especially by planting trees budded on sour orange roots.

Any injury to an orange tree is apt to result in a flow of gum. As we have seen, it is a symptom in both of the above diseases. There are other obscure diseases of the orange in various countries that are accompanied by the exudation of gum. These are collectively known under the name of "gummosis," but none of them have been sufficiently studied to be really understood.

Scab (*Cladosporium*) is a fungous disease causing blisters and distortions on the leaves and young fruits of lemons and sour oranges. It does not attack the sweet orange and usually does no material harm to grape fruit. Sour orange seedlings in the nursery are often so badly attacked by it as to retard their growth and leave them in poor condition for budding. It can be successfully prevented by spraying with Bordeaux mixture.

Sooty mold (*Fumago Citri*, often erroneously called *Meliola Citri*) is a fungus forming a black, crustlike coating on the fruit and leaves. It is not a parasite, and is by no means confined to the orange, but it is a "honey dew" fungus growing on the sweet exudations of certain aphids and scale insects. It greatly injures the appearance, quality, and market value of the fruit, and if abundant lowers the vitality of the tree by obstructing the functions of the leaves. It can be entirely prevented by keeping the trees clear of the insects which furnish its food supply. This, however, is often not an easy matter.

The rust mite (*Phytoptus*) is very abundant in the West Indies and Florida. It is not a true insect, but is related to the spiders and is so small as to be in-

visible without the aid of a strong pocket magnifier. It scarifies the surface of the leaves, young twigs, and the fruits, causing blackish thickenings and discoloration of the leaves and twigs and a peculiar bronzing or russetting of the fruit. These "russet" oranges are well known to the trade and by many are supposed, like russet apples, to represent a distinct variety. This is not the case since all varieties become "russets" when attacked by the rust mite. The damage is entirely external and does not injure the flavor of the fruit. In fact, many people believe that the russets are the sweetest. They do not look as well, however, and "russets" always bring from fifty cents to a dollar a box less than "brights" of the same grade. This mite, like most others of its class, is very susceptible to sulphur fumes. It can be quite successfully controlled by dusting the trees with sulphur, or better still spraying with water containing a little flour paste and flowers of sulphur in suspension. Spraying with sulphide of potash is also very effective, but the effect is less lasting. The treatment should begin very early in the season and should be continued from year to year.

Scale insects of various kinds are among the most troublesome pests of the orange. There are a considerable number of species, but they cannot be considered separately here. When present in considerable numbers on the trunks, branches, or leaves, they greatly reduce the vitality and productiveness of the tree. Young trees may even be killed outright. The fruit, too, is much disfigured when covered by scales. Very fortunately most of the scale insects have numerous

natural enemies that aid materially in holding them in check. They are attacked by minute Hymenopterous parasites, are eaten greedily by various species of ladybirds (*Coccinellidae*) and by certain predaceous Lepidopterous larvae, and in moist regions they are frequently destroyed by various insectivorous fungi. In fact, it may almost be considered a rule that in its native country each scale insect has developed so many natural enemies that under normal conditions it is kept so closely under control as to do but little real damage. Sometimes, however, changes in weather conditions or in other factors favor the scales at the expense of their enemies with disastrous results. Most of the worst outbreaks have occurred when scales have been accidentally imported from one country to another and have thus been able to escape their natural enemies. A striking instance of this kind was the outbreak of the cottony-cushion scale that at one time suddenly threatened to extinguish the California orange industry. The absolute destruction of this scale which followed so promptly after the introduction of its natural enemy, the Australian ladybird (*Vedalia*), was one of the most spectacular triumphs of modern economic entomology. Aside from this introduction of natural enemies two lines of treatment are recognized for scale insects: spraying with caustic contact poisons like kerosene emulsion, whale-oil soap, or the rosin-lime mixtures, or fumigating with hydrocyanic-acid gas. Spraying is much more difficult and unsatisfactory than with deciduous trees, and the fumigation is costly and unless done with great care dangerous. Both treatments have the

great disadvantage of destroying our friends the scale parasites along with the scales. Except in cases of extreme necessity it is probably unwise to attempt the treatment of entire orchards for scale. Great care should be taken in making new plantings to avoid trees from infested nurseries, since this is the way in which this trouble is usually introduced. Close watch should be kept, and individual trees should be promptly treated as soon as scales threaten injury. In this way and by giving good cultivation and general care, expensive general spraying or fumigation, with its wholesale destruction of the useful scale parasites, may usually be avoided. Scale insects seem to multiply faster and do much more damage on feeble, slow-growing trees than on vigorous ones. The greater vigor of growth of young trees on rough lemon roots is thought by some to make them less susceptible to scale than when budded on the sour orange.

The white fly (*Aleurodes*) is an insect closely related to the scales. At the present time in Florida it is more feared than all the other orange pests combined, since its natural enemies have failed to hold it in check and none of the usual remedies seem capable of satisfactorily combating it. It is always accompanied by the sooty mold, which adds greatly to the injury it occasions. It also occurs in Cuba, as specimens of it have been collected there, but so far it is not in sufficient numbers to prove injurious or to attract attention. Whether this practical immunity is due to the presence of more active natural enemies has not been determined. The closely re-

lated guava fly is fairly abundant in Cuba, but it is so freely attacked by a red fungus (*Ashersonia*) and other parasites that it is seldom injurious.

In Cuba a grayish green beetle (*Pachnæus litus*) belonging to the curculios is very abundant and does considerable damage by eating the young orange foliage. This, however, is insignificant compared to the injury caused by the larvæ to the roots. Eggs are laid on the leaves, which soon hatch, when the minute grub falls to the ground, which it at once enters and begins feeding on the bark of the roots. It develops into a white, footless grub about half an inch long, which remains underground till the close of the winter dry season, when it pupates, a fresh crop of beetles emerging with the first spring rains. They sometimes occur in enormous numbers, more than a hundred having been found on the roots of a single small tree, and it really constitutes one of the most serious drawbacks to orange cultivation in the island. The presence of these grubs at the roots is soon indicated by the arrested growth and the yellowing of the foliage. Many trees have been killed outright, but as a general rule they partially recover during the rainy season. Continued attacks, however, greatly retard growth and prevent fruitfulness. Owing to its underground feeding habit, it is very difficult to combat this insect in the larval stage. Before the studies made by the Cuban Experiment Station the connection between the root grub and the green beetle was not suspected. Now that its life history is known it is comparatively easy to control it by destroying the beetles. On small trees

they may be easily picked off by hand, but it is better to take advantage of the fact that like most of their relatives they fall to the ground when jarred or otherwise disturbed. Jarring them onto a sheet stretched over a light frame, such as has been described for the peach curculio, is the most effective method of combating this pest. Spraying with Paris green is also useful, but it cannot be fully relied on, since the beetles, as a rule, only feed on the youngest foliage, and very frequent spraying would be necessary to keep all the young growth effectively poisoned. So far as known this insect is confined to Cuba. Another very similar one is abundant in Porto Rico, feeding on orange foliage, but its life history has not been studied and its larval habit is not known. In Jamaica a much larger and showier curculio (*Præpodes vittata*) does almost exactly the same damage as the Cuban insect, and it has been one of the chief reasons for the practical failure of commercial orange planting in that island. It could doubtless be controlled by the same means that is being found effective in Cuba.

Various species of ants are serious enemies of the orange in some of the tropical countries. Different species of the large leaf-cutting ants (*Atta*) that are known as "bibijaguas" in Cuba do much damage in that island and also in parts of Mexico and Central America, but they are not troublesome in Jamaica and Port Rico. A large tree may be entirely defoliated by a horde of these marauders in a single night. They live in underground cavities in large "ant-hills" and send out their marching

columns to great distances in search of foliage that is just to their liking. This they do not eat, but they cut it up in small pieces and pack it away in their underground chambers, where it becomes covered with a peculiar fungous growth on which the ants feed. It is necessary to search for and destroy all these nests in the neighborhood of orange orchards. This is usually done either by pumping in sulphur fumes or by the use of carbon disulphide. Killing "bibijaguas," however, requires constant attention, since the queens swarm at intervals and scatter out in order to establish new nests. Trees may be temporarily protected from leaf-cutting ants by tying a bit of loose cotton around the trunk or by painting on a ring of the sticky material known to the trade as "tree tanglefoot." This is the same material used in making sticky fly paper. It will remain soft enough to prevent the ants from crossing for a number of days.

Another much smaller ant (*Solenopsis*), known locally as "hormega brava" on account of its vicious sting, does considerable damage in Port Rico and some parts of Cuba by eating holes in the bark of young trees in order to induce a flow of gum. They also bite and destroy the very young twigs. These ants make large shallow nests near the surface of the ground, and great numbers of them can be destroyed by opening these nests with the hoe and sprinkling them with kerosene or rosin-lime mixture. A ten per cent solution of creolin is also useful.

Pomelos (*Citrus decumana*).—The pomelo, or grape fruit, is very closely related to the orange, not

only botanically but in methods of growth and cultivation, and it is subject to the same diseases and insect pests. All that has been said on these heads under oranges will, therefore, apply equally to this fruit. The tree is a rather stronger grower than the orange and tends to come into productive bearing a little younger. The fruit, too, is less delicate and bears handling and shipping better. It will hang on the tree after ripening and keep in good condition for marketing much longer than the orange. It is only recently that it has been extensively introduced in the markets, and its use is still somewhat limited; but the demand is rapidly growing and it bids fair to soon rival the orange in commercial importance. Not much can be said as to varieties at the present time. Marsh seedless is probably being more planted than any other, although it is only medium in size and a little harsh in flavor. It is not absolutely seedless as each fruit usually contains three or four seeds, but most of the other kinds have forty or fifty or more. Just how much of a factor this seedless feature will prove to be in the market cannot yet be determined. The native seedlings found in Cuba are of a rather different type from those of Florida, from which the present market kinds have mostly been selected. The fruit is sweeter and has less of the distinctive grape-fruit bitter. The trees, too, are of a more upright growth. The best of these seedlings are very delicious, having a peculiar sprightly, vinous flavor that is greatly relished by all who try them. They are so mild as to be eaten from the hand, like the orange. One variety of this type was

introduced to the trade some years ago under the name of Royal. It is still listed in the nursery catalogues, but it does not seem to have attracted much attention and is not widely planted. Other kinds of this class are locally just beginning to receive attention. In the Isle of Pines, in particular, one has been selected and planted which is being very favorably received in the market, and it seems probable that these "sweet grape fruit" will soon find a recognized place in the markets by the side of the ordinary bitter ones.

Lemons (*Citrus Limonum*).—The lemon will not bear as much cold as the orange, so that its cultivation is confined to regions that are practically free from frosts. Although closely related to the orange, the tree is of somewhat different habit and requires much more pruning to keep it in productive condition. It has also more of a continuous bearing habit, ripe fruit, half-grown fruit, and flowers being frequently found on the tree at the same time, which, contrary to popular belief, is rarely the case with the orange. It grows and bears well in south Florida, as also in the West Indies, but so far the lemon industry has attained no commercial importance in these regions, largely on account of the difficulty that has been found in curing them so that they will keep well, and thus be able to compete with the foreign and California product. Lemons have to be picked green and then house ripened or cured. Some large plantings are now being made in Cuba, and an earnest attempt will doubtless be made to solve this difficulty. The Villa Franca is the princi-

A Mango Tree.





pal market variety. In a general way lemons are subject to the same diseases and insects as oranges. They are, however, very susceptible to scab, and lemon orchards will have to be sprayed with Bordeaux mixture to secure smooth, marketable fruit.

Limes (*Citrus Limetta*). — Although closely related to lemons, botanically and in the purposes for which they are used, limes are really quite distinct. They are also quite tender to frost. They occur abundantly in south Florida and most parts of the American tropics. They have long been one of the chief crops in certain of the smaller of the British West Indies, where they are grown for pickling and for making commercial lime juice and citric acid. They are also shipped to some extent in the fresh state. It is really remarkable that limes are not more widely known and used at the North. They almost entirely replace lemons for local use in the tropics, and every one who goes there soon learns to greatly prefer them. They have an aromatic quality that makes the lemon seem flat and flavorless by comparison. Some trouble has been experienced in shipping them, since they do not keep as well as lemons, but this is largely due to crude methods in handling them. When the matter of proper handling and curing shall have received sufficient attention, fresh limes will doubtless become a much more important commercial factor. In general, limes are subject to the same diseases and insects as the orange. They are particularly susceptible to a fungous disease known as "wither tip" (*Gloeosporium*), which also attacks many of the other citrus fruits. It causes a spot-

ting of the leaves, attacks and kills the young twigs, and blasts or rots the young fruits. It can be controlled by Bordeaux, and spraying may prove necessary in commercial lime growing.

Commercial citron is the thick preserved and dried rind of another large lemon-shaped citrus fruit (*Citrus medica*). It is found occasionally in south Florida and the islands, but it is nowhere cultivated on a commercial scale.

Tropical Fruits

Among the great numbers of tropical fruits only pineapples and bananas are as yet of any real commercial importance outside of the local markets. Mangoes and avocates are, however, beginning to receive considerable attention, and without doubt the better varieties of them will soon be widely planted for Northern shipment.

Pineapple (*Ananas*).—This fruit is extensively planted for market in south Florida, the Bahamas, Cuba, and Porto Rico, and it is locally important in all the other tropical countries. It will not endure much frost and in Florida it is largely grown under the protection of lathe houses. The partial shade thus afforded seems congenial and adds to the vigor and productiveness of the plants. In the tropics they are usually grown in the open. Occasionally, however, they are shaded by bananas.

Pineapples will grow on a great variety of soils, provided only they are dry and well drained. On damp, heavy soil the plants are short lived and the fruit is lacking in flavor. In Florida most of the



A Pineapple Field.



pine plantations are on what seems to be an old sand dune, and the soil is an almost pure white sand. Of course, large quantities of fertilizer are required. In Cuba, on the other hand, they are grown on the heavy red cane lands without the use of fertilizers. This is possible on account of the remarkable natural underdrainage of these red lands. The additional precaution is also taken of planting on ridges in order to more quickly run off the surface water after rains. In Florida, in order to economize space under the expensive lathe houses, pines are planted very closely on wide beds with narrow paths between the beds. In Cuba, they are planted in single rows with the plants about fifteen inches apart in the row. The sets used for planting are of two kinds, suckers and crowns. The first are side branches. These are broken off and planted during late spring or early summer, and they will produce a crop in twelve months. They are only produced in small numbers, however, so that most of the plantings are made with crowns; a circle of these offshoots comes out at the base of each fruit. They are smaller than the suckers, and it requires eighteen months for them to produce fruit. They are usually planted in late summer or fall.

For distant shipment it is necessary to pick the fruit while it is still quite green. This is unfortunate, since the pine only develops its full sweetness and flavor when allowed to ripen on the plant. Those who have only eaten pines as they appear in the Northern markets can have no idea of what a delicious fruit it really is. A fully ripe pine is, how-

ever, too delicate to stand ordinary shipment. Heavy losses often occur in handling even the green ones, especially if they are picked during or after very wet weather. This loss could doubtless be largely avoided, and the fruit be at the same time marketed in a riper condition by the use of proper refrigerator transportation.

A considerable number of varieties of pines are known, but only a very few are of commercial importance. The one most generally planted for the Northern market is the Red Spanish. This is a small or medium-sized acid pine of rather poor quality, but it is hardy and productive and ships better than any of the others. The Smooth Cayenne and the Porto Rico or Cabazona are two very large pines that are grown in a small way for the fancy trade. While very showy, both are rather acid and cannot be classed as of the best quality. Unfortunately the sweetest, highest-flavored kinds, that are most prized for home consumption, like the Ripley and the Sugar loaf or Piña Blanca, are so delicate that they will not stand ordinary transportation.

As a rule pines are comparatively free from diseases and insect pests. While they have their troubles, these are mostly obscure and unimportant and space cannot be taken to discuss them.

Bananas (*Musa*). — In the space of a single generation the banana has passed from a rare luxury to an article of common everyday necessity, and its production and marketing has developed into an immense industry. The business is largely in the



Bananas.



hands of a single corporation, the United Fruit Company, and this concern alone constantly employs from one to two hundred steamships in carrying bananas from various tropical ports to the United States.

The banana is strictly tropical and will not endure frost. It grows everywhere in the tropics under a great variety of conditions, and it is an important factor in the local food supply. It grows best, however, in deep, rich, alluvial soils, and it is particularly partial to sheltered valleys along streams. The greater part of the bananas grown for export are on river-bottom lands. Jamaica was originally the chief source of supply for the banana ships, and for many years this has been the principal industry of that island. Plantations at various points on the Central American coast have, however, constantly increased in importance, and the larger part of this fruit reaching the United States now comes from that quarter. Cuba produces some commercial bananas, but the conditions are less favorable than in these other countries.

Bananas are propagated by means of suckers that spring up freely from the roots. The usual distance for planting is about fifteen feet apart each way. Cultivation is very simple, consisting simply in keeping down grass and weeds with the hoe or cultivator. New lands are preferred for bananas, when possible. The timber is cut down and burned and the plants are set among the blackened stumps without plowing or other preparation of the soil. A great effort is usually made to keep these new-land plantations free from grass. Men go around with sacks and pull up

and carry from the field every bunch of grass that makes its appearance. This is much cheaper than attempting to cultivate in lands that are already infested with grasses, and it is astonishing how large an area a single man can keep absolutely clean by this method. In the older districts suitable new lands are no longer available, and this method cannot be employed. Each sucker produces a bunch of fruit in about fifteen months. When the fruit is cut, the stalk dies and makes room for the growth of the new suckers that have sprung up from its roots. The same plantation thus produces fruit continuously for many years, but constant care is needed in thinning out the suckers or they will soon become too crowded to produce salable bunches. The crop is a continuous one throughout the year, but it is much heavier at some seasons than at others, this mainly depending on the distribution of the rainfall. The time of fruiting can also be controlled to some extent when thinning the suckers, by saving only those of a certain size which will naturally bear at the desired season.

Bananas are always cut green even when intended for home consumption. If allowed to hang on the stalk, they ripen unevenly, so that many are wasted and the quality is no better than when house ripened. The bunches are handled and loaded in bulk without packing of any kind. Ships for the banana trade need to be especially constructed so as to allow for a free circulation of air below decks and to be abundantly provided with ventilator funnels. More than one cargo has rotted and been dumped overboard

for lack of these requirements. Bananas do not carry well under refrigeration, but tend to blacken and soften quickly. Good ventilation is, however, very essential.

A great number of varieties are known, but there is great confusion in regard to their proper names. Only one is ordinarily planted for Northern shipment. This is known as the Dominica in Jamaica, as the Johnson in Cuba, and as the Jamaica in some of the other countries. A large red banana is also sometimes seen and seems to be gaining favor in the markets. The dwarf Cavendish variety, or "Enana," is a favorite in the English market, but this is more delicate and each bunch is usually crated separately. The "Datil," or date banana, is a very small, high-flavored kind that is much prized for home consumption, but is practically unknown at the North. It is quite firm and would carry well. By a little effort it might easily be introduced to the fancy trade, but it is not prolific enough and is too small to ever compete with the Dominica in the general market. The "Manzana," or apple banana, is a medium-sized kind, having a trace of acid which gives its flavor a supposed resemblance to that of an apple. It is much relished by some and is the leading kind in the Havana market, but it is seldom shipped as it does not carry well. The various cooking bananas or plantains are an exceedingly important article of food throughout the tropics, where they are used both in the green and ripe stage. They are either baked or fried. They are sold to some extent in New Orleans and the Florida cities, where there are many Cubans and

other Latin Americans who are accustomed to them, but they are practically unknown at the North. Their quality as a vegetable is really so good that a demand could doubtless be created for them by a little properly directed effort. In most tropical markets they sell for double the price of the table kinds.

Bananas are singularly free from fungous and insect troubles. A bacterial top rot attacks the stalks in some parts of Cuba and a serious disease of an unknown character has appeared at a few points in Central America. The decay of the fruit is sometimes hastened by the attack of an anthracnose (*Glæosporium*), but little study has been given to these troubles and no remedies can be suggested.

NUT CROPS

Pecans and cocoanuts are the only ones of sufficient importance to require special mention. Peanuts have already been referred to under forage plants, but on some of the lighter soils in the middle South they are grown extensively as a market crop. They can be grown successfully in all parts of the South on the lighter, drier soils and also in most tropical regions. They do not thrive on wet, heavy soils.

Pecans (*Hicoria Pecan*).—This is a native forest tree in many parts of the South extending north along the river bottoms as far as southern Illinois. The large, thin-shelled or so-called paper-shelled types that are now in cultivation came originally from Texas and Louisiana. They can be grown in practically all parts of the cotton belt, but the large

commercial plantings are mostly confined to the coast region. Few of the planted groves have yet reached full bearing, and most of the commercial supply still comes from wild trees. The pecan is very variable and does not come true from seed. Much disappointment has followed the planting of even the finest selected seeds, since more than half of the trees produced are likely, after years of waiting, to produce only ordinary inferior nuts. Pecans are very difficult to propagate by the ordinary methods of budding and grafting. A fairly successful method of patch budding or inlaying has, however, been devised, and budded trees of named varieties may now be secured from the leading Southern nurseries. The price for these budded trees is quite high, owing to the difficulty of production, but it is better to use them for commercial planting rather than to risk the uncertain quality of seedlings. Since the pecan grows into a large forest tree, it is necessary to plant them at a considerable distance ; forty to fifty feet is none too much, but the space between may be utilized for other crops or for planting peaches or other orchard trees. Heavy applications of nitrogenous fertilizers should be used in order to hasten growth and bring the trees more quickly up to the bearing size. The worst drawback to the pecan industry is the length of time that must elapse before returns can be expected. Well-grown trees may produce a few nuts when six or seven years planted, but profitable crops cannot be expected for a much longer period. A number of insect and fungous pests occur, but no discussion of them can be attempted.

Cocoanuts (*Cocos*). — Cocoanuts are widely planted in most tropical countries. Formerly they were an important crop at many points in the West Indies, but the wide spread in recent years of the disease known as "bud rot" has practically wiped out the industry at many points where it was once most flourishing. At the present time it would be an unsafe investment to plant cocoanuts in any of the islands where the disease is known to occur. The few groves in southern Florida have not as yet been attacked by it. Cocoanuts will grow under a great variety of conditions, but they thrive best near the sea, and they will grow and bear well even where they are occasionally drenched with salt spray. Their cultivation is very simple. The fully ripe nuts are gathered as they fall and are placed close together in nursery beds for germination without removing the thick outer husk. They germinate best when only partially covered with soil. After two or three leaves have formed the young tree, nut and all, is moved to its permanent location. It is hoed around a little for the first year or two, after which it practically shifts for itself. Nuts will be produced in from six to ten years according to location and care. The nuts are produced in large clusters at the top of the tree. These are produced in constant succession, several bunches with nuts of different sizes being seen on the tree at the same time, so that the crop is a perpetual one. The nuts fall as they ripen, when they are picked up, the thick, fibrous outer husk is cut away, and they are ready for market. Besides their

use in the fresh state they are largely used for oil making. Some well-marked varieties occur and individual trees are known to vary greatly in productiveness and in the size and quality of the nuts, but as is the case with so many tropical products almost no attention has been given to selecting these better strains for propagation.

Cocoanut bud rot is one of the most destructive of known plant diseases. The foliage on a thrifty bearing tree suddenly turns a little yellowish and the petioles of the great leaves will droop a little and stand at a slightly wider angle, and the immature nuts will begin to fall. It takes a keen eye to catch this first symptom of trouble in the leaves and to differentiate it from the yellowing caused by scale insects or other troubles, but the falling of the young fruit is an almost certain symptom of incipient bud rot. As the disease progresses the yellowing and general demoralization of the foliage becomes more pronounced, until finally the entire top of the tree suddenly blackens and falls away, leaving the trunk standing as a leafless stump. Sometimes the oldest leaves will not be affected, but will remain green for a time after the bud and upper younger leaves have rotted and fallen. The disease seems unquestionably to be a bacterial one, although this has not as yet been absolutely proven by successful inoculations with pure cultures of the germ. Dissections of the diseased trees at any stage will show more or less extensive areas where the young tissues are being attacked by a soft watery rot. When this finally reaches the large

central terminal bud, the whole mass of soft tissue of which it is composed is quickly reduced to a stinking pulp and the upper leaves topple over and fall. The disease, when once established, spreads gradually from tree to tree in ever widening circles. The exact manner in which the contagion is conveyed is not known, but it is probably carried by insects. It has been observed that the disease advances faster with the prevailing wind than against it. All ordinary remedial measures are powerless to reach a disease of this character and so far the planters have been helpless in trying to stay its progress. Some claim that touching a match to the dead leaves and trash always found hanging in the top of a cocoanut tree and thus disinfecting it by fire will often arrest the disease in its incipient stages. The observed facts indicate that this may be the case, but exact experiments are lacking. Theoretically the prompt cutting out and burning of all infected trees as soon as the disease can be detected should arrest the disease and perhaps ultimately stamp it out from any given locality, but the experiment never seems to have been tried on a sufficiently thorough and extensive scale to afford a demonstration.

Scale insects of various kinds often attack the cocoanut and do considerable harm. The leaves turn yellow when attacked, and the tree loses vigor and in some cases even dies, but this is very rare.

The leaves are also often spotted and discolored by the growth of various fungi. It is probable that some of these fungous parasites are responsible for a

peculiar wasting disease that is sometimes observed when the leaves gradually grow smaller and smaller and finally dwindle away entirely. These other troubles are, however, all insignificant as compared with the bud rot.

TRUCK CROPS

The name of truck farming has come to be applied to the growing of the different garden vegetables on an extensive scale for distant shipment. This is a business of great magnitude in many parts of the South, and since the American occupation it is coming to be of considerable importance in Cuba. Vegetables also are shipped North in a limited way from certain parts of Mexico.

A great variety of soils are successfully employed for trucking, but light, sandy loams are usually preferred, and most of the great trucking centers are on lands of this character. Alluvial and muck soils are also suitable for most of the truck crops. Other things being equal, of course, naturally rich soils are to be preferred to poor ones, but a suitable mechanical texture seems to be more important than chemical composition and many of the most extensive trucking districts are located on what are naturally very poor lands. Such soils, of course, require heavy manuring or the free use of chemical fertilizers combined with leguminous restorative crops. In fact, a proper understanding of the use of fertilizers is one of the first requisites for a successful truck farmer.

Of even greater importance than the proper selection of soils and fertilizers is the question of trans-

portation. Some at least of the truck crops can be grown successfully by proper management under almost any soil and climatic conditions that permit of agricultural operations of any kind, but they can only be profitably marketed from those points that have the most adequate transportation facilities. It thus follows that the trucking industry has clung close to the Atlantic seaboard within reach of cheap steamer transportation and to certain of the great North and South trunk railroad lines, where the management has been intelligent enough to recognize its importance and to give it the necessary facilities and encouragement. So large has the annual movement become that it now constitutes one of the most important items of business on a number of the leading Southern railroads and of the coastwise steamship lines.

A large number of vegetables are grown and shipped as truck at different points in the Southern states. The following alphabetical list, while by no means complete, covers all that are of much importance.

Asparagus	Peas
Beans	Peppers
Beets	Potatoes
Cabbage	Radishes
Cantaloupes	Spinach
Carrots	Squash
Celery	Sweet Potatoes
Egg Plant	Tomatoes
Kale	Turnips
Lettuce	Watermelons
Onions	

It is impossible within the limits of this volume to attempt a detailed discussion of each of these numerous crops. A few remarks of a general nature must suffice. For most of them, of course, the seed is simply planted in the field where it is to grow. Unlike the others, asparagus is a perennial. The seed is planted in seed beds or nursery rows, where the plants are allowed to grow from one to two years. The old and expensive plan of deep trenching for asparagus is unnecessary except perhaps on very heavy lands. Its chief requirements are a good permeable soil and the very abundant use of manure and fertilizers. Cabbages, celery, egg plant, peppers, and tomatoes are usually planted in seed beds or in cold frames and the plants are moved to the field when from four to six weeks old. In the more northerly districts it is usual to sow the seed of the last three in hotbeds that are heated by manure or other artificial heat and are protected by glass frames or sash. When the first rough leaves appear, the seedlings are pricked out into cold frames that are protected by glass or by cotton cloth which is reënforced by hay or other covering during cold snaps. These frames are, of course, opened during the day when the weather will permit. The proper care of such plant beds is a matter requiring experience and good judgment. From the cold frames the plants are carried to the field, usually with a ball of dirt, as soon as the danger of frost is over. By this method it is possible to secure crops from four to six weeks earlier than when the seed is planted in the open air. In southern Florida and the tropics these methods are, of course, unnecessary.

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The seed of these crops may there be planted directly in the field and the plants then thinned to a stand, but even here it is more usual to plant in seed beds and move them to the fields when from six to eight inches high.

Sweet potatoes (*Ipomoea*) deserve a word of special mention, not only because they are widely grown as a truck crop, but from their importance in the home economy of every Southern farm. They are grown as universally as are Irish potatoes at the North, and not only furnish a standard vegetable for the table but are much used for stock food. The vines, too, make a rich forage. They are particularly useful for hogs. These animals are turned into special fields, planted for the purpose, to dig for themselves, or after the crop is harvested they are allowed to glean the roots and small potatoes that have been missed in digging. The small potatoes that are unfit for market make excellent feed for milch cows and horses.

At the North sweet potatoes are always propagated by bedding the small ones in the spring and pulling up the numerous sprouts that spring from them to take to the field. At the South a small field is usually planted in this way in the spring, but the main plantings are made at midsummer with vine cuttings taken from this early field. In the tropics vine cuttings only are used, since they are available all the year round. This custom has, however, led to the gradual loss of productiveness. Experiments have shown that by occasionally returning to the Northern method and planting the suckers that spring from the potatoes themselves the yield can be very considerably

increased. They are always planted on raised beds or ridges.

Sweet potatoes are rather difficult to keep through the winter. For best results a rather warm uniform temperature and a dry atmosphere are required. In the large trucking districts special storage houses are provided with some means of artificial heating. The ordinary small farmer at the South, however, keeps them with considerable success by "holing them up" in the ground as is done with apples and Irish potatoes at the North. The hole must, however, be thoroughly drained and the potatoes kept from actual contact with the dirt by the free use of dry grass or pine straw. A ventilating pipe must also be left in the top of the pile, and it is best to provide some temporary shelter to keep off the rain.

In Cuba the number of truck crops is much more limited; only potatoes, onions, tomatoes, egg plant, and peppers are of much importance. These are all strictly winter or dry-season crops. They are mostly grown with irrigation, but some of the sandy lands in Penar del Rio province have such good moisture-holding capacity that good crops can be produced without it. Potatoes yield less than at the North, for though usually of good size they are few in the hill. Only the Bermuda onion is grown. Sets imported from the Canary Islands are used, since but poor success has been had in growing them from seed. Tomatoes grow well and yield well for a time, but profitable picking can usually only be secured for from three to four weeks, when the foliage is attacked by leaf mold and the fruit becomes too small for shipment.

Successive plantings are necessary in order to keep up continuous shipments. Egg plants and peppers grow and yield well for a long period, but the former are subject to a stem blight or wilt that frequently causes heavy losses.

Among the distinctively tropical vegetables there are three that deserve some especial mention from their importance in the local markets and as a source of home food supply, though as yet they are unknown in Northern commerce. These are yams, cassava, and malangas, or yautias.

Yams (*Dioscorea*).—The true yams are the large, irregular starchy tubers of tall-growing vines belonging to various species of *Dioscorea*. Sweet potatoes are often called yams in the Southern states, but this is not the proper use of the word. Yams require a moist, rich soil that is well supplied with vegetable matter. They are planted in large hills or in rather high ridges in order to secure perfect drainage, and tall stakes are necessary for the vines to climb on. Pieces of the tubers are planted for seed the same as with the potato. It requires about twelve months for the crop to mature. The tubers are large, often weighing several pounds each. They are used in the same manner as potatoes, but they are more nutritious and constitute one of the most important of the tropical food crops. The tubers keep indefinitely while undisturbed in the ground, but they cannot be kept long after digging.

Cassava (*Manihot*).—The sweet cassava, or "yuca," as it is called in Spanish-speaking countries, is another tropical food crop of much importance. The

term "cassava" in Spanish is applied to a kind of bread made from the starchy roots and not to the plant itself, as in English. The roots of the bitter cassavas, which closely resemble the sweet varieties in appearance, contain hydrocyanic acid and therefore are poisonous. They are, however, largely employed in starch making. Cassava starch is of superior quality. As the yield per acre is much greater than with potatoes, there is reason to suppose that the starch industry of the tropics will ultimately prove to be of great importance. The long, fleshy roots (not tubers) constitute the edible part of the plant. They are cut up in sections and boiled like potatoes. They do not become mealy, but remain wet and soggy, and though on account of their easy production they are very widely used, they do not compare as a food with either yams or malangas. Besides its use for food and in starch making cassava furnishes a good stock food, being eaten by both hogs and cattle. It can be grown with some success in Florida and along the Gulf coast, where it has attracted considerable attention as a forage plant. It is propagated by means of cuttings of the stems. These grow very readily. The plant is not particular as to soils, but will thrive on a great variety of them and will give fair yields on land that is too poor for most other crops. The plant is perennial, and the roots continue to increase in size for a number of years. They soon begin to get woody, however, so the crop is usually dug in from twelve to eighteen months. Roots of edible size are produced in six to eight months if conditions are favor-

able. The number of varieties both of the sweet and bitter kinds is very great, and there is always some danger of the two becoming confused. Accidents from this cause are, however, infrequent since the bitter taste serves to distinguish those that are poisonous.

Malangas or Yautias (*Xanthosoma*).—These are the names used in Cuba and Porto Rico, respectively, for the edible tubers produced by various species of *Xanthosoma*, plants closely related to, and greatly resembling, the common *Caladium*, or elephant's ear, of Northern conservatories and gardens. "Taro" (*Colocasia sp.*), the famous food plant of the Hawaiian Islands and the East, is a very similar plant, that also occurs in the West Indies, and is often confused with the others under the same names. Other local names are applied to these plants in different American tropical countries, and everywhere they constitute an important local food supply. They grow well on almost any good soil, but are particularly adapted to moist, rich alluvial lands. In favorable locations they yield enormously. They are used the same as potatoes; they are even more nutritious, and the better varieties are equally palatable. Unlike yams and cassava the tubers keep almost indefinitely when dug if stored in a dry place. They are propagated by cutting up the old or so-called "mother" tuber, which, though still edible, is not equal for food to the new offshoots. Forty or fifty distinct varieties have been recognized, though most of them are very local, usually only a few kinds being known and planted in any given region.

FORESTRY

While forestry is, perhaps, not strictly a branch of agriculture, yet the influence of forests on agricultural conditions is so great that a few words on the subject will not be out of place. Until the last very few years this vitally important question has received no attention whatever at the South. The great natural pine and hardwood forests have been ruthlessly cut down for lumber, or to clear the land for farming, with no thought for the future timber supply, or for the bad effect of this wholesale deforestation on the climate; and annual fires have prevented the growth of new forests on what are otherwise waste lands. In the tropical countries the story is the same. Countless acres of valuable hardwoods have been cut down and burned to make room for sugar and coffee plantations, and the remaining forests are being ransacked for cedar and mahogany. The time has at last arrived when the general public is beginning to realize the immense importance of preserving forest conditions in all rough, mountainous regions that are unfit for cultivation, and even some of the large lumber companies who, in the past, have been among the most ruthless of destroyers, are beginning to adopt means for harvesting their mature timber without ruining the young trees and preventing the reforesting of the land. The Europeans long ago learned to so manage forests as to make them a perpetual source of income. No lesson is more needed in all the American countries than this one.

Deforestation has already reached the point

where the future timber supply is seriously threatened. The commercial planting of forests to meet this prospective demand has already begun, and it is destined in the near future to reach much greater proportions. Persons embarking in this business, however, at the South, will be greatly handicapped by lack of knowledge as to the cultural possibilities and needs of the principal Southern timber trees. Very little data is at hand as to the best methods of propagation and management, or as to the rate of growth and time required for maturity of the different species. In the American tropics this lack of knowledge is so great as to be almost absolute. Whether or not such valuable timber trees as West Indian cedar and mahogany can be profitably grown on what would otherwise be waste land in those regions where they are native, but where they are now so rapidly vanishing, is a question of vast economic importance, but it is one that will require years of expensive experimentation to determine. Questions of this kind, which require so many years before practical results can be expected, are difficult of solution by private enterprise, but they are preëminently suitable subjects for research stations that receive government support. The time has now come when extensive scientific experimentation in both forest planting and forest management is urgently needed at the hands of each of the American governments.

DOMESTIC ANIMALS

No general agricultural treatise can be considered complete without at least some reference to those

domestic animals that play so important a part in all farm economy. A full discussion of this subject as it applies to the South and to the tropics would, however, require a separate volume or rather a series of volumes. Space here will only permit of a few general remarks and considerations.

Climatic conditions favor animal husbandry at the South, since expensive shelters are not required and pasturage and other green forage can be furnished for the greater part of the year, thus avoiding the necessity for curing and storing large quantities of hay. It is true that the familiar Northern pasture and hay grasses cannot be successfully grown, but there are many others to take their places. Bermuda is as good as bluegrass for permanent pastures, while cowpeas, vetch, crab grass, and Johnson grass can be made to take the place of timothy and clover for hay. Under these circumstances it is an economic anomaly that the South has been for so long a time dependent on the North for her supply of horses and mules, beef, butter, lard, and pork, when as a matter of fact she might be producing them cheaper than is possible in the regions from which they are imported. This condition has probably largely come from the pernicious system of annual leases that prevails so widely throughout the cotton belt. The poor ignorant negro farm hands are usually each allotted a certain number of acres to be cultivated on shares. As cotton is the chief money crop, he is required to plant it all in cotton and is furnished a mule and is given credit at the store for his meal and pork. He has no incentive for building

up the fertility of the soil and neither the knowledge, the inclination, nor the means for embarking in stock breeding. In those sections where the farmers own and work their own lands attention is being rapidly turned to more diversified farming and the production of home food supplies.

In Cuba and other parts of tropical America the cattle industry has long been an important one. Here cattle graze throughout the year and receive no feed aside from the luxuriant pasturage. If means were taken to improve the breeding of these herds and some provision were made, which might easily be done, for growing some forage with which to supplement the pasturage during the pinch of the dry season, the beef from these wonderful Guinea and Para-grass pastures might quickly become an important factor in the world's markets.

A word in regard to each of the more important kinds of live stock must close this very inadequate treatment of a most important subject.

Horses and mules thrive well in all parts of these Southern countries. They are subject to no serious diseases that are not familiar at the North, though horses when first taken South require a few months in which to become acclimated before they are fit for very heavy work.

The heavy draught breeds of horses do not seem to stand hard work in hot climates as well as mules, and for all heavy work these animals largely take their place in Southern countries. Millions of dollars are spent annually by Southern farmers to buy mules in the middle West. Even in tropical regions the

mule is gradually but surely crowding out the ox as a work animal. With abundant cheap pasturage it costs but little more to raise a two-hundred-dollar mule than a forty-dollar ox, and it is most surprising that the subject of mule breeding is not receiving more attention in all of these Southern countries.

At the South and in the tropics cattle imported from the North are attacked by the serious disease variously known as Texas fever, tick fever, or splenic fever. It is caused by a minute parasite of the red blood corpuscles that is very similar to the one causing malarial fevers in man. In the case of the cattle disease, however, the parasite is carried, not by mosquitoes, but by certain species of cattle ticks. Native Southern cattle have all become immune to this disease although the parasite is still present in their blood, and hence they are constantly infecting the ticks which bite them. The presence of even a few of these ticks on imported Northern animals will quickly induce the disease. A method of artificial immunization has, however, now been devised which consists in inoculating the animals to be treated with fresh blood serum taken from an animal that is known to be immune. The toxine contained in this serum induces a slight attack of the fever, which renders the animal immune to future natural tick inoculations. By previously immunizing young Northern cattle in this way they can be taken South or to the tropics with the loss of not over 10 per cent and frequently of less than 5 per cent, while without this treatment the loss would run from 50 per cent to 90 per cent. It is now,

therefore, perfectly possible to import breeding animals of the best strains for grading up Southern herds for both beef and dairy purposes. These ticks, though not able to cause disease in native or immunized cattle, are often so abundant as to prove a veritable scourge and to greatly retard growth. The animals may be cheaply freed from these pests by running them occasionally through dipping tanks which contain contact insecticides. A thin skim of crude petroleum floating on water is often used for this purpose, but for hot weather some of the arsenical dips are found to give less discomfort and to be equally effective. Practical methods have also been devised for permanently freeing pastures from ticks, and they are being adopted by some of the more progressive Southern cattle men.

The opinion prevails quite widely that the South is not adapted to dairying. This is a great mistake, for by the use of centrifugal separators most excellent butter can be made at any point in the South or the tropics, where a small amount of ice can be secured for cooling and ripening the cream. The fact that more butter and cheese are not made in these regions of cheap and perpetual pasturage only indicates a lack of knowledge and enterprise on the part of the stockmen and farmers.

Hogs, too, should be much more largely raised at the South. There is no excuse for the unnumbered trainloads of bacon, hams, and lard that are constantly pouring into a region where besides corn such useful hog foods as cowpeas, peanuts, chufas, rape, and sweet potatoes are so easily and cheaply grown. In

Cuba and the other regions where the Royal palm is abundant, its rich, oily fruits or nuts furnish a nutritious hog food which is always in season, each tree ripening from nine to twelve large bunches in succession during the year. This is practically the only hog food used in these countries, but it might easily be supplemented not only by the crops mentioned above, all of which grow readily in these regions, but by sugar cane, the stalks of which are greedily eaten by hogs, and by the very productive cassava and malanga as well. Notwithstanding these obvious advantages for hog raising, every steamer bound southward carries lard, hams, and other hog products as an important part of her cargo. There seems to be no special hog disease at the South. Cholera is sometimes a great scourge, as at the North, but outbreaks can usually be controlled by proper isolation and quarantine.

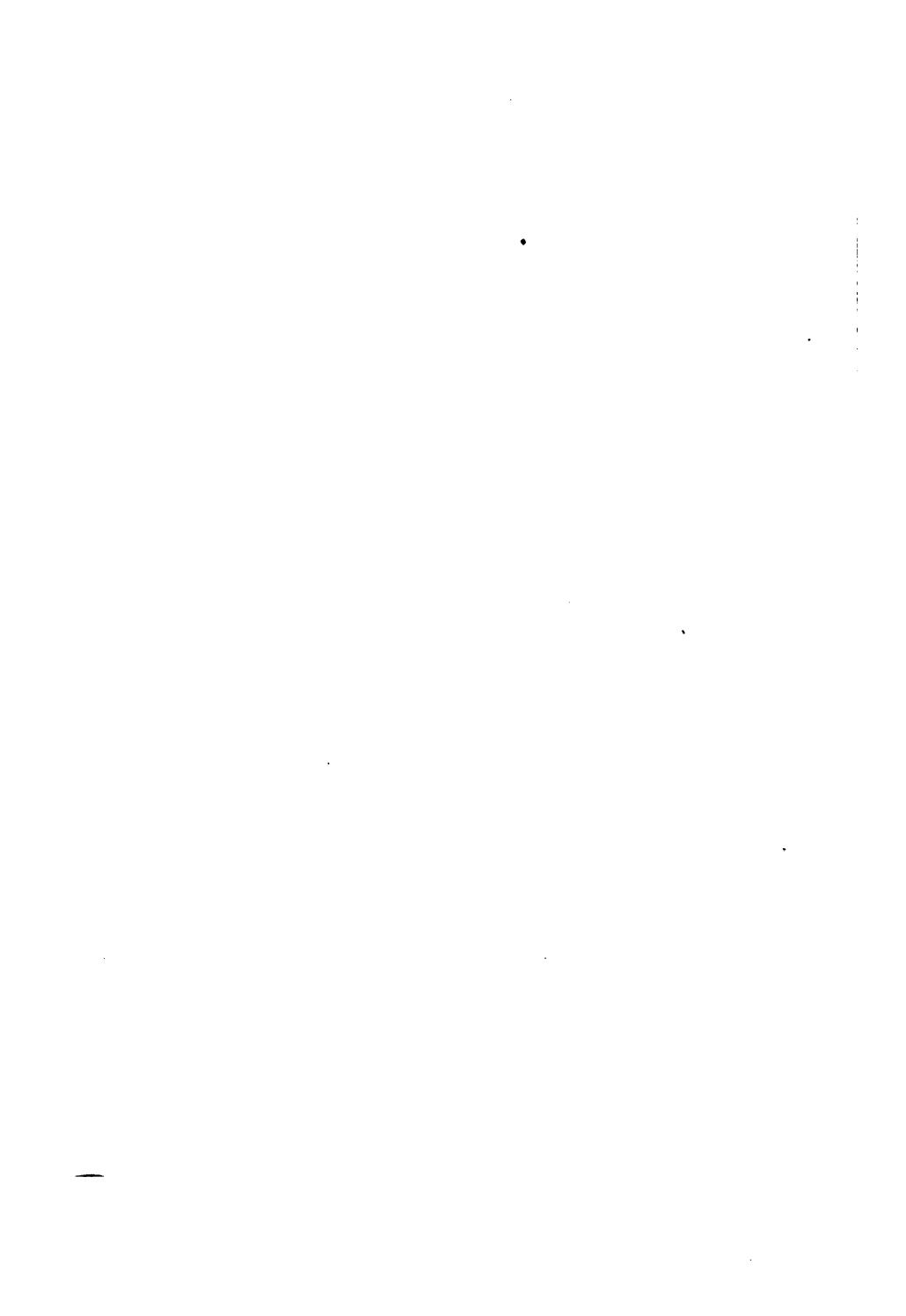
Sheep raising is another industry that should receive more attention. Much of the hill lands that are comparatively worthless for other purposes are admirably adapted for sheep, and even the low, sandy savannahs near the Gulf coast, contrary to the ordinarily accepted belief, make most excellent sheep ranges and support considerable flocks throughout the year without any other food. Besides the annual clip of wool the early spring lambs are always in demand at good prices. The worthless dogs that so infest the South are the worst enemies of the sheep raiser but wherever this industry has gained much importance means are readily found for their destruction. While the usual sheep diseases occur,

they are no more troublesome than in more northerly latitudes. In the tropics sheep soon lose a part of their woolly coating and hence are only valuable for mutton. They thrive there fairly well, however, and as they can be raised with a minimum of care and expense, they deserve more attention for this purpose than is generally given them.

Goats are very hardy, prolific animals, that are particularly well adapted to all warm climates. In southern Europe they play an important part in the agricultural economy, but here they are usually looked upon more as a nuisance than a source of profit. They will, however, live and thrive where the pasturage is too poor to support any of the other domestic animals. The flesh, especially of the young animals, is very good food, notwithstanding the American prejudice to the contrary, and the skins furnish a valuable article of commerce. The number and aggregate value of the goatskins annually imported into the United States are so great as to be almost unbelievable. The best milk strains produce a very large quantity of milk and butter fat when compared with the quantity and value of the food consumed. It seems probable, therefore, that in the future these animals will occupy a much more important place in Southern agriculture than they do at present.

Poultry and eggs are universally raised in the South and in the tropics for home consumption, and their sale in the local markets adds materially to the income of many households. Their attempted commercial production on a large scale has often resulted in failure, since to be successful it requires a large

amount of special knowledge and experience and the closest possible attention to details. There is probably somewhat more trouble from mites and other parasites than at the North, and some diseases occur that are not known there, like the so-called "sore head" that is so troublesome with young chicks hatched during the rainy summer season. These disadvantages are, however, more than offset by the mild climate that allows poultry to range throughout the year and by the cheap and varied food supply. The entire region offers an inviting field for chicken fanciers and expert breeders. Every farm should unquestionably produce an abundance of chickens and eggs for household purposes with a margin over for the grocer, and much more attention should be given to the breeding of improved strains and races; but those without expert knowledge of the business should make haste slowly in embarking on large commercial poultry enterprises until this knowledge has been gained by considerable practical experience.



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